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To comply with Federal requirements of the Federal Water Pollution Control Act Amendments of 1972, the General Accounting Office undertook an extensive study of water pollution problems and Federal water pollution research, development, pilot, and demonstration (R & D) programs to determine whether Federal R&D programs were producing the results necessary to help clean up the Nation's waterways. It sought answers to the following questions: What has been accomplished? What needs to be done to achieve national water pollution control goals?

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REPORT TO THE CONGRESS

Research And Demonstration Programs To Achieve Water Quality Goals: What The Federal Government Needs To Do

B-166506

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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JAN. 16, 1974

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-166506

To the President of the Senate
and the Speaker of the House of Representatives

This is our report on Federal water pollution research and demonstration programs which was undertaken pursuant to section 5 of the Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251 note). The act required the Comptroller General to conduct a study of the research, pilot and demonstration programs related to the prevention, abatement and control of water pollution which are conducted, supported or assisted by any agency of the Federal Government and assess the conflicts between and the coordination and efficacy of such programs.

The report highlights the accomplishments and problems of the research and demonstration programs and the additional efforts required to achieve the goals of the 1972 amendments to the Federal Water Pollution Control Act.

We have considered the comments of various Federal departments and agencies and other organizations on the matters discussed in this report and have incorporated their formal comments in the appropriate sections.

Copies of this report are being sent to the Director, Office of Management and Budget; the Chairman of the Council on Environmental Quality; the Chairman of the National Commission on Water Quality; the Administrator, Environmental Protection Agency; and other Federal departments, agencies and organizations having cognizance over matters included in our study.

Elmer B. Staats

Comptroller General
of the United States

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UNITED STATES GENERAL ACCOUNTING OFFICE

REPORT TO THE CONGRESS

Research And Demonstration Programs To Achieve Water Quality Goals: What The Federal Government Needs To Do

B-166506

VOLUME 1

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

GLOSSARY

Bioaccumulation	An organism's uptake and retention of substances from its environment, as opposed to uptake from its food.
Bioassay	Using organisms to determine the biological effect of some substance, factor, or condition.
Biochemical oxygen demand	A measure of the oxygen consumed in the biological processes that break down organic matter in water. Large quantities of organic wastes require large amounts of dissolved oxygen. The more oxygen-demanding matter, the greater the pollution.
Combined sewers	Carry both sanitary sewage and storm water runoff. During dry weather, combined sewers usually carry all the waste water to the treatment plant. During a storm, only part of the mixed flow is carried to the plant due to overloading; the rest is discharged, untreated, into waterways.
Cooling tower	A device to remove excess heat from water used in industrial operations, notably in electric power generation.
Crustacaen	A class of arthropods, including lobsters, shrimps, crabs, etc., commonly having the body covered with a hard shell or crust.
Ecological impact	The total effect of an environmental change, either natural or manmade, on an area's ecology.

Ecosystem	The interaction of a biological community and its nonliving environment.
Effluent	The waste water discharged by an industry or municipality.
Estuaries	Areas where freshwater meets saltwater, i.e., bays, mouths of rivers, salt marshes, and lagoons. Estuaries serve as nurseries and spawning and feeding grounds for large groups of marine life and provide shelter and food for birds and wildlife.
Eutrophication	The process whereby a lake becomes overfertilized from too many nutrients, especially phosphorus and nitrogen. As a result, algae and other plant life become overabundant, and the lake may evolve into marshland.
Heavy metals	Metallic elements with high molecular weights, generally toxic in low concentrations to plant and animal life. Such metals are often residual in the environment and exhibit biological accumulation. Examples include mercury, chromium, cadmium, arsenic, and lead.
Infiltration	Occurs when water enters sewers and sewer connections through defective joints, broken or cracked pipes, improper connections, and manhole walls.
Microbes	Minute plant or animal life that cause disease. Some microbes exist in sewage.

Mollusks	A large group of invertebrates, including chitins, snails, bivalves, squids, and octopuses, characterized by the calcareous shell of one, two, or more pieces that wholly or partly encloses the soft, unsegmented body provided with gills, mantle, and foot.
Navigable waters	The waters of the United States.
Nutrients	Elements or compounds essential as raw materials for organism growth and development; e.g., carbon, oxygen, nitrogen, and phosphorus.
Organic	Referring to or derived from living organisms. In chemistry, any compound containing carbon.
Pollutants	Any introduced gas, liquid, or solid that makes a resource unfit for a specific purpose.
Salinity	The degree of dissolved solids in water.
Sludge	The solid matter removed from waste water through treatment. Sludge handling involves the processes that remove solids and make them ready for disposal. Disposal may involve incineration, dumping in waterways, or land application.
Stabilization ponds	Manmade impoundments that hold waste water. The holding process permits solids to settle out and biological decomposition to occur.
Thermal pollution	Degradation of water quality by the introduction of a heated effluent, which is primarily a result of the discharge of cooling

	waters from industrial processes, particularly from electrical power generation. Even small deviations from normal water temperatures can affect aquatic life.
Toxicity	The quality or degree of being poisonous or harmful to plant or animal life.
Water pollution	Manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water.
Water quality criteria	Levels of pollutants that affect the suitability of water for a given use.
Water quality standard	A plan for water quality management which considers the use to be made of the water, criteria to protect those waters, implementation and enforcement plans, and an antidegradation statement to protect existing high-quality waters.

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ABBREVIATIONS

AEC	Atomic Energy Commission
ARS	Agricultural Research Service, Department of Agriculture
AST	Applied Science and Technology
BOD	biochemical oxygen demand
DOD	Department of Defense
EPA	Environmental Protection Agency
GAO	General Accounting Office
GPO	Government Printing Office
NTIS	National Technical Information Service
OMB	Office of Management and Budget
OR&D	Office of Research and Development, EPA
OWRR	Office of Water Resources Research, Department of the Interior
R&D	research, pilot, development, and demonstration
SIE	Science Information Exchange, Smithsonian Institute
WRSIC	Water Resources Scientific Information Center, Department of Interior

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

RESEARCH AND DEMONSTRATION PROGRAMS
TO ACHIEVE WATER QUALITY GOALS:
WHAT THE FEDERAL GOVERNMENT
NEEDS TO DO B-166506
VOLUME I

DIGEST

WHY THE REVIEW WAS MADE

The 1972 amendments to the Federal Water Pollution Control Act directed the Comptroller General to study and report on Federal research and demonstration (R&D) programs to find new ways to make the waters of the United States cleaner.

The Comptroller General was asked to determine the

--conflicts between,

--coordination of, and

--effectiveness (i.e., the power to produce results) of

the various Federal programs.

GAO sought answers to three basic questions:

--What are the central issues?

--What has been accomplished?

--What needs to be done to achieve national water pollution control goals?

GAO was assisted by experts in various disciplines of environmental science and engineering. (See p. 10.) GAO also sent questionnaires to the 50 States, 100 municipalities, and 74 national trade associations.

FINDINGS AND CONCLUSIONS

The 1972 amendments established

--the goal of providing, by 1983, water quality sufficient for protecting and propagating fish, shellfish, and wildlife, and for recreation;

--the goal of eliminating, by 1985, the discharge of pollutants into navigable waters; and

--a national policy that a major R&D effort be made to develop the technology necessary to eliminate the discharge of pollutants into navigable waters, waters of the contiguous zone, and oceans.

During fiscal years 1969-73, 12 Federal departments and agencies spent about $495 million--including $238 million spent by the Environmental Protection Agency (EPA)--for water pollution R&D.

EPA's R&D funding remained about the same--about $50 million annually--during fiscal years 1969-72. The other Federal agencies' R&D funding increased from $36 million to $71 million in the same period.

In fiscal year 1973, EPA funding decreased from $50 to $42 million.

Central issues

At current funding levels for water pollution R&D, it is doubtful that the 1985 deadline for zero discharge will be met. Both management and coordination of R&D programs need to be improved.

What has been accomplished?

EPA has three broad R&D programs:

--Research to determine how pollutants get into the water, what happens to them, and what is their effect. (This is called processes-and-effects research.)

--Technology to find new ways to treat municipal sewage. (This is called municipal technology development.)

--Technology to find new ways to control pollution from industrial or other sources (called nonpoint) such as agriculture.

During fiscal years 1969-73, EPA:

--Obtained scientific data on some pollutants' lethal and safe levels affecting a few species of aquatic life. Some of this data has been or will be used in establishing water quality standards.

--Achieved a better understanding of certain aspects of the premature aging of lakes and developed standard procedures to measure the effects increased amounts of phosphorus and nitrogen have on the aging process.

--Improved municipal waste water treatment processes.

--Developed and demonstrated new water pollution control processes that have industry-wide application for some industries.

Other Federal agencies' R&D results have been useful in

--providing basic information on the effects of pollutants on man and his environment,

--developing technology to control pollution from nonpoint sources, and

--assisting State and local agencies and private industry in their efforts to control water pollution. (See pp. 22 to 32.)

What needs to be done to achieve national water pollution control goals?

To carry out the 1972 amendments, EPA will need to

--establish and enforce water quality standards,

--regulate the dumping of wastes into the oceans,

--provide financial assistance to States and municipalities to construct waste treatment facilities, and

--limit the amount of pollutants in waste water (effluents) that can be discharged from point sources such as industrial.

Much R&D remains to be done to achieve water quality goals. The following seven sections summarize the R&D needed to achieve the act's goals. (See pp. 33 and 34.)

1. *Processes-and-effects research needed to support water pollution control programs*

Important processes-and-effects research, needed to establish water quality standards, has not been completed and EPA objectives remain to be met. (See pp. 34 to 40.)

Research on thermal discharges (heated water) from power plants has been delayed because of limited funding. There is need for additional research to study the effects and obtain a better understanding of such discharges. (See pp. 40 to 42.)

In May 1973, EPA stated that attention will be directed toward researching

--the effects of water pollution, to set standards for fresh and marine waters;

--health effects, to set standards for drinking and recreational waters; and

--the effects and methods of controlling thermal discharges.

These research areas are of high priority. (See pp. 43 and 44.)

It is important that, over the next several years, processes-and-effects research be coordinated with the development of effluent limitations based on advances made in water pollution control technology. As EPA develops and uses sound effluent limitations in its regulatory activities, the need for some processes-and-effects research may diminish.

2. *Minimizing the cost of treating municipal sewage--a prime objective*

Municipal technology R&D funding has decreased 64 percent over the last 7 years, while funding of EPA's construction grant program has increased about 3,200 percent.

In 1967, when the Federal Government obligated $150 million for the grant program, $26.2 million was applied to the technology development program; in 1973, about $3 billion was obligated for the grant program compared to only $9.5 million, or about 0.3 percent, for technology development.

In comparison, the Department of Transportation's Urban Mass Transportation Administration, which has $1 billion for its annual capital grants program, is spending about 8 percent, or $80 million, on research. Also, the national average of research expenditures by industry is about 4 percent of net sales.

EPA officials estimated that $225 million was needed for fiscal years 1973-78 to meet municipal technology development objectives. At the present funding level of $9.5 million, this would take about 24 years.

EPA's program has been directed primarily toward refining or modifying existing municipal treatment processes. This has resulted in higher levels of pollutant removal but many municipalities consider the processes too costly.

GAO believes that one of EPA's primary goals should be to find ways to minimize the cost of treating municipal sewage.

In 1972 EPA estimated that it would cost about $153.8 billion for municipalities to achieve zero discharge by 1981. The 1972 amendments authorized the appropriation of $18 billion during fiscal years 1973-75 for grants to help construct waste water treatment facilities. (See pp. 44 to 47.)

Huge sums of money are expected to be spent on constructing and operating municipal treatment plants. Even relatively small percentage cost savings, applied broadly, would result in

--increased probability of earlier construction because municipalities could more easily finance and operate new facilities and

--wider distribution of Federal funds to construct more treatment plants.

3. *Technology needed to control pollution from industrial and nonpoint sources*

The 1972 amendments provide industry to apply the best:

--Practicable control technology available (defined by EPA as removing 85 percent of the pollution), by July 1, 1977.

--Available technology economically achievable (defined by EPA as removing 95 percent of the pollution), by July 1, 1983.

The amendments also establish a goal of zero discharge by 1985. (See p. 48.)

Measuring progress toward these goals is a problem because EPA officials were not fully aware of the R&D efforts of other agencies, private industries, and the States, except when EPA participated in funding projects. They estimated that, as of June 1973, the range of established goals attained for industry was as follows:

--60 to 95 percent of the best practicable control technology.

--20 to 40 percent of the best available control technology.

--5 to 20 percent of the technology needed for zero discharge.

Several national industrial trade associations believed EPA's estimates were optimistic. (See pp. 49 and 50.)

The act establishes a 1985 national goal of zero discharge for nonpoint sources of pollution. EPA estimated that 5 to 90 percent of the technology development goals for nonpoint sources had been attained.

EPA estimated that additional Federal funding of $543 million would be needed to develop the technology to achieve the stated goals. If its estimate is reasonable, this would take more than 45 years at current funding levels.

Anywhere from 5 to 7 more years

may be required to allow for implementation of the technology. (See pp. 48 to 51.)

4. *Need for a water pollution R&D strategy*

EPA had not developed a strategy setting forth its R&D goals, objectives, and priorities since it was formed in December 1970. Guidance provided to agency R&D planners was broad. (See pp. 51 to 53.)

5. *Making EPA's R&D program more responsive to operating programs*

The objective of EPA's R&D program is to support establishing and enforcing water quality standards and financial assistance programs for State and municipal water pollution control.

Toward these ends EPA needs to

--improve the implementation of its R&D program planning system (see pp. 53 to 57),

--establish procedures for revising water quality criteria more frequently on the basis of new research results (see pp. 57 and 58),

--publish the results of its processes-and-effects research sooner and make such data available to those who set standards and take enforcement action (see pp. 58 and 59), and

--make sure that the program to control pollution from industrial and nonpoint sources better supports R&D needs of enforcement and standard setting (see pp. 59 and 60).

6. *Need for national plan to improve coordination of water pollution R&D*

A national water pollution R&D plan--comprising all available expertise and resources--aimed at improved coordination of R&D efforts is needed if water pollution control goals are to be achieved with all possible efficiency, economy, and effectiveness.

EPA should develop such a plan in cooperation with Federal and non-Federal organizations and enlist their assistance in putting the plan into effect.

Some industrial representatives told GAO that industry was reluctant to furnish EPA with certain information relating to its R&D activities because it feared EPA might use the information to speed up enforcement action. (See pp. 73 and 74.)

Within the Federal sector, EPA will have to rely on the voluntary cooperation of other Federal agencies to make the plan work. The support of the Office of Management and Budget (OMB) is essential. (See pp. 67 to 69.)

7. *Need for a Federal focal point to coordinate the dissemination of research information*

Federal agencies had not coordinated their flow of R&D results to interested parties.

Designating a Federal agency as a focal point to coordinate and promote the dissemination of water pollution research results should alleviate these problems and foster better use of Federal research information by potential users such as universities, States, and municipalities. (See pp. 80 to 93.)

RECOMMENDATIONS

The Administrator, EPA, should prepare an R&D strategy to carry out EPA's R&D requirements under the 1972 amendments, estimate the amount of money needed to meet these requirements, and present this information in EPA's annual report to the Congress. (See p. 65.)

To improve the coordination of Federal water pollution R&D programs, GAO recommends that the Administrator, EPA

--develop, in cooperation with Federal and non-Federal organizations, a national water pollution R&D plan and

--seek the cooperation and support of these organizations in implementing the plan. (See p. 77.)

In view of OMB's role in promoting efficiency and economy in Government operations, the Director, OMB, should participate with EPA in obtaining the full cooperation of all Federal agencies engaged in water pollution R&D in the development and implementation of a national water pollution R&D plan. (See p. 78.)

The Director, OMB, should also designate a Federal agency as a focal point to coordinate and promote the dissemination of water pollution research results. (See p. 92.)

GAO also made several other recommendations to correct deficiencies discussed in this digest. (See pp. 65 and 66.)

AGENCY ACTIONS AND UNRESOLVED ISSUES

EPA, 11 other Federal departments and agencies involved in water pollution R&D activities, and

--OMB,

--the Department of State,

--the Council on Environmental Quality,

--the National Academy of Sciences,

--the Smithsonian Science Information Exchanges,

--the Great Lakes Basin Commission,

--the International Joint Commission for the Great Lakes

were requested to review and comment on all or part of this report.

For the most part, general concurrence with GAO's report was indicated. Their comments are included, as appropriate, in pertinent sections of this report.

EPA stated that GAO's recommendations were constructive criticisms which will help it direct its R&D efforts toward achieving the goals of the Federal Water Pollution Control Act Amendments of 1972. (See pp. 13, 66, 70, 72, 78, 92 and 93.)

Agencies and organizations and their formal comments are included in appendixes I and II.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Attaining the goals established by the 1972 amendments will require an ambitious R&D effort within a relatively short period of time. At the current funding levels for water pollution R&D, it is doubtful that these goals will be achieved within the time period established by the Congress. Therefore, the Congress should consider the current and planned funding levels for water pollution R&D in relation to the research needed to determine if increased funding is warranted.

The 1972 amendments established a commission (the National Commission on Water Quality) to study the technological aspects of achieving the effluent limitations and goals set forth for 1983, as well as all aspects of the economic, social, and environmental effects of achieving or not achieving these limitations and goals. The Commission is required to report to the Congress by October 1975.

If the Congress finds it necessary, as a result of the Commission's study, to reassess and revise legislative goals, the Congress should determine the direction of Federal R&D programs--in terms of priorities and funding levels--to meet the revised goals. (See p. 66.)

EPA relies on industry's voluntary release of information on its R&D efforts and results in deciding which R&D water pollution projects to pursue. As previously stated, GAO became aware of some reluctance by industry to provide such information.

A free and full exchange of such information--under proper safeguards to avoid public disclosure of proprietary information and under assurances that such disclosure will not adversely affect the industry's pollution control program--should be of mutual benefit and should help avoid unnecessary duplication of R&D.

The Congress may wish to explore with EPA and industry whether current procedures for exchanging such information can be strengthened. (See p. 79.)

CHAPTER 1

INTRODUCTION

The Federal Water Pollution Control Act Amendments of 1972 became law on October 18, 1972. Section 5 of the amendments (33 U.S.C. 1251 note (Supp. II, 1972)), states that:

> "In order to assist the Congress in the conduct of oversight responsibilities the Comptroller General of the United States shall conduct a study and review of the research, pilot, and demonstration programs related to prevention and control of water pollution, including waste treatment and disposal techniques, which are conducted, supported, or assisted by any agency of the Federal Government pursuant to any Federal law or regulation and assess conflicts between, and the coordination and efficacy of, such programs * * *."

SCOPE OF STUDY

To comply with the above provision, GAO undertook an extensive study of water pollution problems and Federal water pollution research, development, pilot, and demonstration (R&D) programs to determine whether Federal R&D programs were producing the results necessary to help clean up the Nation's waterways. We sought answers to the following questions:

--What has been accomplished?

--What needs to be done to achieve national water pollution control goals?

Our study was directed toward determining whether the programs were (1) providing the scientific data needed to support regulatory actions to improve environmental quality and (2) developing and demonstrating new and improved technology that industries and municipalities could use for preventing, abating, and controlling water pollution.

We also ascertained whether the

- --R&D programs were directed toward supporting the goals and objectives of the Federal Water Pollution Control Act Amendments of 1972;
- --R&D programs were coordinated to avoid conflicts, duplication, and overlapping research; and
- --results of R&D programs were disseminated to and used by interested parties.

We concentrated on the Environmental Protection Agency (EPA), including its predecessor agencies,[1] because it has the largest program and is primarily responsible for protecting the environment. We looked at other Federal agency R&D efforts primarily to identify their specific areas of interest and to determine the adequacy of interagency coordination.

To assist us in our study, we hired 12 consultants with expertise in various disciplines of environmental science and engineering.

These consultants included:

Dr. David C. Chandler, Retired
Former Director, Great Lakes Research Division
University of Michigan

Dr. James E. Etzel
Head, Environmental Engineering Department
University of Purdue

Dr. Ernest F. Gloyna
Dean, College of Engineering
University of Texas

---

[1] See app. III for a chronology of EPA's predecessor agencies which had responsibility for administering water pollution R&D programs.

Dr. George P. Hanna, Jr.
Dean, College of Engineering and Architecture
University of Nebraska

Dr. Cornelius W. Kruse
Professor and Chairman
Department of Environmental Health
School of Hygiene and Public Health
Johns Hopkins University

Dr. G. Fred Lee
Professor and Head
Environmental Chemistry Engineering
Civil Engineering Department
Texas A&M University

Dr. Ross E. McKinney
Parker Professor of Civil Engineering
University of Kansas

Mr. DeWitt O'Kelly Myatt
President
Science Communication, Inc.

Dr. Daniel A. Okun
Kenan Professor of Environmental Engineering
Head of Department of Environmental Sciences and Engineering
School of Public Health
University of North Carolina

Dr. Gerald A. Rohlich
Professor, Environmental Engineering and Public Affairs
University of Texas

Professor Robert O. Sylvester
Professor and Head of Water and Air Resources
Department of Civil Engineering
University of Washington

Dr. Leon W. Weinberger
President
Environmental Quality Systems, Inc.

We also contacted numerous other scientists and engineers; sent questionnaires to the 50 State water pollution control agencies, 74 industrial trade associations, and 100 large municipalities; visited Federal agencies' headquarters and regional offices, State agencies, municipal departments, Federal environmental research centers and laboratories, private corporations, and R&D projects; and examined Federal agencies' documents, records, studies, and other literature.

REPORTING

The results of our study are contained in a two-volume report with three supporting enclosures. This volume summarizes the results of our study, and volume II contains the results of our study of Federal R&D programs in a geographic area--the Great Lakes. Pertinent details on the following programs are contained in the three supporting enclosures.

Enclosure	Content
A	Programs to determine the sources, fate, and effects of water pollutants.
B	Technology development programs for solving municipal waste water treatment problems.
C	Programs to control water pollution from industrial, agricultural, mining, and other sources.

FEDERAL FUNDING

The following schedule shows the Federal agencies involved in water pollution R&D and the estimated funding for the 5 fiscal years 1969-73. Appendixes II through V contain additional funding information.

FY 1967-1973

Department or agency	Estimated funding (000 omitted)
EPA	$238,067
Department of the Interior	116,323
Department of Agriculture	49,449
Atomic Energy Commission (AEC)	37,629
Department of Transportation	18,168
Department of Defense (DOD)	9,358
Corps of Engineers, Department of the Army	3,234
National Science Foundation	10,889
Department of Commerce	6,416
Department of Housing and Urban Development	2,623
National Aeronautics and Space Administration	1,641
Tennessee Valley Authority	777
Department of Health, Education, and Welfare	82
Total	[a]$494,656

[a] This may not represent the total effort of these agencies. We were unable to determine exact funding levels because agencies (1) used different terminology to classify their R&D efforts or (2) did not keep detailed figures in their accounting records.

AGENCY COMMENTS

We requested the 12 departments and agencies involved in water pollution R&D activities, the Office of Management and Budget (OMB), the Department of State, the Council of Environmental Quality, the National Academy of Sciences, the Smithsonian Science Information Exchange, the Great Lakes Basin Commission, and the International Joint Commission for the Great Lakes to review and comment on our report.

These agencies and organizations indicated general concurrence with our report. Where appropriate, their comments are included in pertinent sections of the report. EPA stated that our recommendations were constructive criticisms which will help it direct its R&D efforts toward achieving the goals of the Federal Water Pollution Control Act Amendments of 1972. OMB did not provide formal comments on our report. The list of agencies and organizations and the formal comments received are included in appendixes I and II.

CHAPTER 2

WATER POLLUTION AND FEDERAL R&D PROGRAMS

> "Our water resources, more perhaps than any other, illustrate the interaction of all parts of the environment and particularly, the recycling process that characterizes every resource of the ecosystem * * * Everything that man himself injects into the biosphere--chemical, biological or physical--can ultimately find its way into the earth's water. And these contaminants must be removed, by nature or by man, before that water is again potable."[1]

Water pollution is a national problem that affects everyone is some manner. In 1971 about 29 percent of the Nation's stream-miles were polluted to the point that they violated Federal water quality standards. Eliminating the problem will not be a simple task, because pollution originates from many sources and has many forms. R&D provides the scientific and engineering knowledge needed for sound regulatory actions and for developing new or improved pollution control technology. Although EPA conducts the largest Federal water pollution R&D program, 11 other departments and independent agencies also conduct R&D programs.

WATER POLLUTION--ITS NATURE, SOURCES, MAGNITUDE, AND EFFECTS

Water pollution, broadly defined, is the addition of harmful or other objectionable material to water in sufficient quantities to degrade water quality. Pollution results when unwanted animal, vegetable, or mineral matter enters water and makes it dangerous for drinking, recreation, agriculture, industry, or wildlife.

What are the most significant sources of water pollution?

Various sources--mining, power generation, dredging, watercraft, and others--contribute to water pollution, but, according to EPA, the three most significant sources are (1) industry, (2) municipalities, and (3) agriculture.

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[1] Charles C. Johnson, Jr., former Assistant Surgeon General of the United States, in a speech to the American Waterworks Association on September 4, 1969, at Ocean City, Maryland.

Industry discharges the largest volume and the most toxic of pollutants. Total output of organic wastes from water-using industries is estimated to have a pollution strength three to four times greater than the domestic sewage handled by all municipalities. Moreover, new synthetic chemicals being developed could produce new and more exotic types of wastes for the future.

Municipal wastes contain large amounts of organic materials, dissolved minerals, and often residues from industrial wastes handled by municipal treatment plants. Each year about 1,000 communities outgrow their treatment facilities, resulting in large amounts of raw or inadequately treated sewage flowing into waterways.

Agricultural sources of water pollution include livestock wastes, irrigation return flows, and land runoffs containing concentrations of highly toxic pesticides and herbicides. The use of chemical fertilizers and pesticides to attain higher agricultural productivity has increased significantly during the last decade.

A source of pollution that could be of increasing significance is the discharge of heated waste water, primarily from power-generating plants. Such thermal discharges change the water temperature and may affect fish and other aquatic life adversely. Because of the increased demand for power, the potential for thermal pollution is expected to increase nearly ninefold by the year 2000.

What are the effects of water pollution?

The effects of water pollution are varied. Some are obvious, such as surface oil slicks, large fish kills, and public health notices warning citizens not to swim or wade in the water. But pollution may also create less obvious changes in aquatic life, such as a decrease in the number of sport or commercial fish and an increase in the number of less desirable fish. Nutrients, particularly phosphorus and nitrogen, stimulate growth of excessive quantities of algae and other plant life which causes lakes to eventually dry up. The excessive growth of algae also affects the taste of water, causes odors that interfere with a lake's use as a source of drinking water, clogs filters in water treatment plants, kills off desirable types of fish, and interferes with swimming and other recreation.

To what extent have our waterways been polluted?

In general, every part of the Nation has some pollution but to differing degrees. Extensive pollution is found in the Ohio, Great Lakes, and Southeastern river drainage basins. These three areas contain 24 percent of the Nation's stream-miles and 49 percent of the polluted stream-miles. EPA officials have stated that many of the Nation's estimated 100,000 small lakes are in serious trouble, and the National Academy of Sciences reported in 1972 that one-fifth of the near-shore ocean shellfish grounds have been closed because of pollution. (See pp. 4 to 9, enc. A, for more details.)

FEDERAL LEGISLATION

Federal water pollution control legislation has a long history. Two major pieces of legislation enacted in recent years are discussed below.

The National Environmental Policy Act of 1969

This act directs all Federal agencies to (1) administer their programs in a manner consistent with the policy of protecting and restoring the quality of the environment, (2) consider environmental protection in all agency decisions, and (3) assume initiative in tackling the Nation's environmental problems.

Federal Water Pollution Control Act Amendments of 1972

The amendments declared that the objective of the Federal Water Pollution Control Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. To achieve this objective it established the following major goals, policies, and requirements.

Goals

--By 1985 eliminate the discharge of pollutants[1] into navigable waters.

--By July 1, 1983, achieve, wherever attainable, an interim goal of water quality which provides for protecting and propagating fish, shellfish, and wildlife and which provides for recreation in and on the water.

Policies

--Prohibit discharge of toxic pollutants in toxic amounts.

--Provide Federal financial assistance to construct publicly owned waste water treatment works.

--Make a major R&D effort to develop the technology necessary to eliminate the discharge of pollutants into navigable waters, waters of the contiguous zone, and oceans.

Requirements

--By July 1, 1977, achieve effluent limitations[2] for point sources[1] other than publicly owned treatment works by applying the best practicable control technology currently available as defined by the Administrator, EPA.

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[1] The amendments define the term "pollutant" as dredged spoil, solid waste, incineration residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

[2] According to the act, restrictions established by a State or the Administrator on quantities, rates, and concentrations of chemical, physical, biological, and other constituents discharged from point sources.

--By July 1, 1983, achieve effluent limitations for point sources other than publicly owned treatment works by applying the best available technology economically achievable as defined by the Administrator, EPA.

--For publicly owned treatment works, application of:

1. Secondary treatment for all facilities approved for construction before June 30, 1974, or in existence on July 1, 1977, or the technology necessary to meet more stringent limitations established to achieve water quality standards or standards that are part of a schedule of compliance by July 1, 1977.

2. Best practicable waste treatment technology by July 1, 1983.

EPA's responsibility under the legislation

Since 1970 EPA has been responsible for cleaning up the Nation's waterways. Under the 1972 amendments EPA is authorized to

--review and approve water quality standards and set effluent limitations;

--take enforcement action against those who discharge pollutants in violation of permit conditions or limitations into rivers, streams, lakes, estuaries, and oceans;

--disapprove waste water discharge permit applications if the discharge will excessively pollute the receiving water;

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[1] According to the act, any discernible, confined, and discrete conveyance from which pollutants are or may be discharged.

--provide financial assistance to States to control and restore the water quality of lakes; and

--develop comprehensive programs for preventing and eliminating pollution by participating in, cooperating, and coordinating with others the research, investigations, demonstrations, and other similar actions relating to the causes, effects, extent, prevention, and abatement of pollution.

R&D--THE FEDERAL ROLE AND FEDERAL PROGRAMS

The basic role of Federal water pollution R&D is to provide the basis for developing a strong, coherent program for achieving high-quality water.

Federal water pollution R&D programs can be divided into two general categories--water quality research and technology development. Water quality research involves determining the sources, fate, and effects of water pollutants. It provides the scientific basis for establishing water quality standards and for predicting how substances being discharged into the water will affect water quality. Technology development programs are directed toward developing and demonstrating new or improved methods, processes, and techniques to control water pollution from industrial, municipal, agricultural, and other sources.

Federal water pollution R&D activities are being conducted and/or supported by 12 departments and independent agencies. EPA conducts its R&D activities under a program specifically for improving water quality in support of the agency's mission under the Federal Water Pollution Control Act. The primary objective of most of the other agencies' R&D activities is to support their missions to protect and enhance our natural resources or to solve water pollution problems relating to their programs or activities.

EPA R&D ACTIVITIES

The objective of EPA's R&D program, which is administered by the Office of Research and Development (OR&D), is to support its (1) regulatory function of establishing and enforcing environmental standards and (2) State and municipal water pollution control financial assistance programs. (See app. VIII for OR&D's organizational structure.) The program consists of three broad categories:

- --Research into pollution processes and effects.
- --Development of technology to control pollution from municipal sources.
- --Development of technology to control pollution from industrial, agricultural, and other nonmunicipal sources (Applied Science and Technology (AST) program).

Research into pollution processes and effects

This research addresses the sources, fate, and effects of water pollutants. It provides the scientific data needed for developing new and improved water quality criteria and establishing standards which define acceptable pollutant levels. These standards, in turn, serve as the basis for enforcement. The data is also necessary for evaluating the effectiveness of proposed abatement techniques. Detailed information on processes-and-effects research is in enclosure A.

Municipal technology development

This R&D program involves developing and demonstrating new or improved technology to control pollution from sanitary sewer, storm sewer, and combined sewer discharges; nonsewered runoff; and joint municipal-industrial waste. The program is also concerned with increasing the efficiency of municipal systems, demonstrating methods to handle and dispose of sludge, and developing and demonstrating nutrient removal techniques. Detailed information on technology development programs for solving municipal waste water treatment problems is in enclosure B.

AST program

The objective of this segment of EPA's R&D program is to support agency enforcement and standard-setting activities by developing and demonstrating (1) new technology for abating and controlling water pollution from nonmunicipal sources and (2) new technology to reduce the cost of treating water pollution from such sources. Included among these are industry, agriculture, mining, and other sources, such as recreation, watercraft, construction projects, and spills and discharges of oil and hazardous materials. Detailed information on the AST program is in enclosure C.

OTHER FEDERAL AGENCIES' R&D ACTIVITIES

Water pollution R&D programs are also being conducted and/or supported by 24 bureaus, services, and offices within 11 departments and independent agencies, each with separate missions, each funded under different programs, and for the most part, authorized under separate legislation. (See app. IX for a summary of the missions of six Federal agencies with significant water pollution R&D activities.)

CHAPTER 3

EFFICACY OF FEDERAL R&D EFFORTS IN WATER POLLUTION

Efficacy is defined as the power to produce results--effectiveness. This chapter summarizes our assessment of the extent to which Federal R&D efforts were effective in helping to solve the Nation's water pollution problems.

The need for water pollution R&D has become more important in recent years as our Nation's waterways have become more polluted. To control and eliminate pollution, the sources, fate, and effects of pollutants on man and his environment need to be determined and methods to control the pollutants or prevent them from entering the water need to be developed.

Federal R&D programs have contributed to improving the quality of some of our waterways, but much more remains to be done and the management and coordination of these programs need to be improved if the goals of the 1972 amendments are to be achieved effectively and on time. A lack of sufficient funds has been and probably will continue to be a major impediment to achieving those goals.

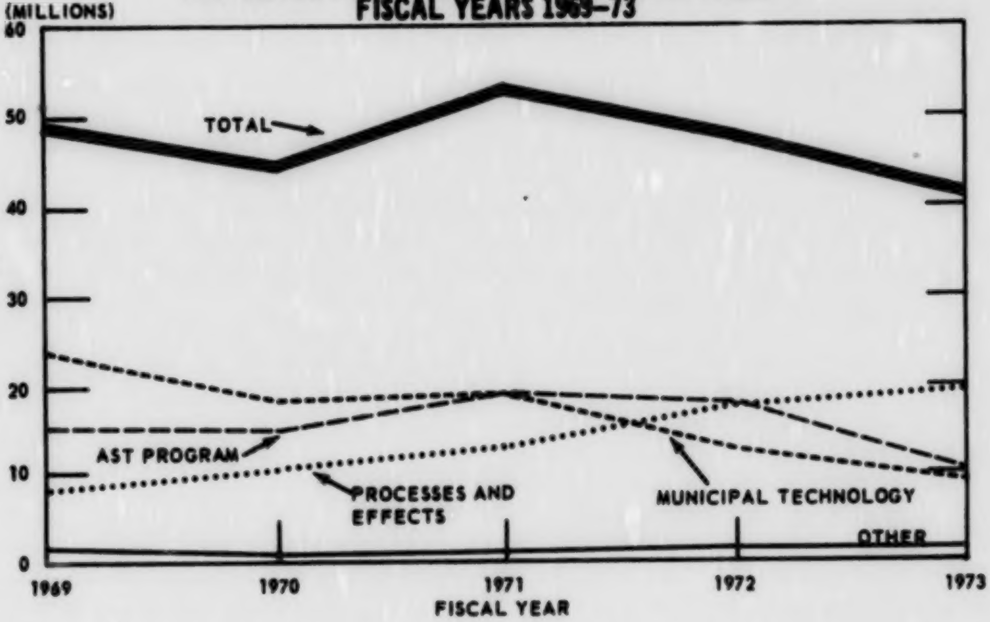
WHAT HAS BEEN ACCOMPLISHED?

We estimate that Federal agencies funded a total of $495 million for water pollution R&D during fiscal years 1969-73. EPA alone funded about $238 million for water pollution R&D. The following table shows EPA's total funding, by major research category, for the 5-year period.

	(millions)
Processes and effects	$ 68
Municipal technology	84
AST program	80
Other	6
Total	$238

The following graph shows EPA funding for each fiscal year.

EPA'S INHOUSE AND EXTRAMURAL FUNDING FOR WATER POLLUTION R&D BY EPA CATEGORIES FISCAL YEARS 1969-73



As the graph shows, EPA's funding for municipal technology and AST R&D programs decreased during the 5-year period whereas processes-and-effects research funding increased. Overall, total R&D funding decreased from $50 million in fiscal year 1969 to $42 million in fiscal year 1973. During this period EPA, in its budget requests to OMB, requested $340 million; the President, in his budgets to the Congress, requested $272 million; the Congress appropriated $258 million, which included carryover funds from prior years; and EPA obligated $238 million.

Through its R&D program, EPA has:

--Obtained scientific data on some pollutants' lethal, sublethal, and safe levels affecting a few species of aquatic life. The results of some of this research were used or will be used in developing water quality criteria.

- --Obtained a better understanding of certain aspects of lake eutrophication and developed standard procedures to measure the effects increased nutrient levels have on lakes.

- --Improved existing municipal waste water treatment processes and helped municipalities through the use of demonstration grants.

- --Developed and demonstrated new water pollution control processes that have industrywide application for some industries, such as sugar beet processing and fiberglass manufacturing.

Several other Federal agencies conducted or supported R&D activities related to water pollution. They spent approximately $257 million during fiscal years 1969-73. (See app. V.)

The results of these agencies' R&D efforts have been useful in (1) providing basic information on the effects of pollutants on man and his environment, (2) developing technology to control pollution from sources, such as runoff from animal feedlots, oil spills, and erosion, and (3) assisting State and local agencies and private industry in their efforts to control water pollution.

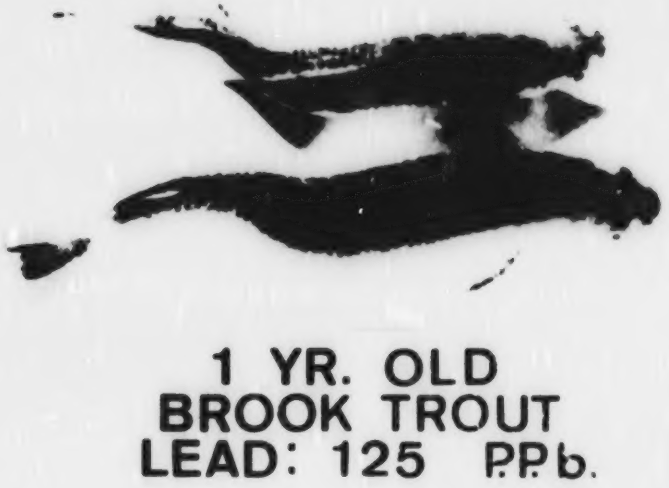
The scope of the agencies' R&D activities, however, was generally limited to specific water pollution problems related to their missions and was not directed toward a comprehensive water pollution R&D program.

Developing water quality criteria

One ingredient necessary for an effective water pollution control enforcement program is the establishment of water quality standards based on water quality criteria. Water quality criteria are developed by EPA and others through scientific investigations which determine the levels of pollutants that affect the suitability of water for a given use. EPA and the States need these criteria to establish sound and enforceable water quality standards. Water quality standards protect aquatic life by limiting the amount of pollutants that can be present in a body of water having an approved use, such as the propagation of fish for recreational or commercial value.

EPA's processes-and-effects research produced scientific data on some pollutants' lethal, sublethal, and safe levels affecting a few species of aquatic life, and the results of some of this research were used or will be used in developing water quality criteria for certain species of aquatic life. For example, EPA was studying the effects of lead on three generations of brook trout. The results from this study will be used to develop freshwater quality criteria for establishing water quality standards.

The pictures below show the effects of lead on second-generation brook trout spawned and reared for 1 year in clean water and water containing 125 parts per billion (p.p.b.) lead. The parents of the deformed fish were exposed to lead 7 months before their spawning.


1 YR. OLD
BROOK TROUT
LEAD: 125 P.P.b.

SPINAL DEFORMITIES APPEARED IN BROOK TROUT EXPOSED TO 125 p.p.b. LEAD

1 YR. OLD
BROOK TROUT
CLEAN WATER

NO APPARENT DEFORMITIES IN BROOK TROUT REARED IN CLEAN WATER

(EPA photographs)

EPA's accomplishments, however, were quite limited when compared with the research objectives established by EPA that remain to be achieved. EPA officials informed us that little of the processes-and-effects research had been completed to develop water quality criteria needed by the States to set sound water quality standards. They said that processes-and-effects research will be a never-ending effort because of the (1) introduction of hundreds of new potential pollutants, such as synthetic chemicals, each year, (2) complex nature of water pollution, and (3) limited amount of research funds. Consequently, EPA officials were unable to estimate the total cost and magnitude of required processes-and-effects research. (See pp. 10 to 35, enc. A, for more details.)

Restoring lake water quality

When a lake is excessively fertilized by large quantities of nutrients (including phosphorous and nitrogen) from industrial, municipal, and other sources, algae grows rapidly, causing accelerated eutrophication which limits the use of the lake for recreation and as a source of drinking water. The following photographs show the results of excessive fertilization.

SURFACE OF LAKE COVERED WITH ROOTED VEGETATION (ABOVE) AND ALGAE AND SCUM (BELOW). SUCH EXCESSIVE GROWTH INTERFERES WITH USE OF THE LAKE FOR RECREATION AND AS A SOURCE OF POTABLE WATER.

(EPA photographs)

During fiscal years 1969-72, EPA spent about $8 million on eutrophication research to (1) understand the accelerated eutrophication process, (2) develop predictive models of the eutrophication process, and (3) develop nutrient control techniques.

EPA funded 41 extramural basic research projects to investigate the mechanisms involved in accelerated eutrophication. The projects were to provide a basis for applied research aimed at modeling the process and developing control techniques. The results of some of these projects provided a better understanding of certain aspects of eutrophication, but, overall, it is still not understood very well.

Program officials said that some of the basic research projects provided a basis for developing initial models of the eutrophication process, which will ultimately lead to predictive models, and that some models are being developed which must be validated on numerous bodies of water by using data before and after restoration programs are initiated.

EPA did research to develop standard modeling methods for assessing the response of freshwater algae to changes in nutrient levels. A standard laboratory assay procedure was developed which was considered highly successful. Work on continuous flow and field assays has not been completed, and standard salt water assays need to be developed. Work on developing standard procedures to index and quantify the degree of lake eutrophication has been limited.

EPA conducted several research projects to develop nutrient control processes, but few of these projects involved full-scale demonstrations. Many of the projects, in their early stages of development as of June 1973, were for evaluating nutrient diversion, advanced waste treatment, nutrient inactivations, aeration, sediment dredging, and sediment drying.

EPA program officials informed us that they do not expect to have sufficient research results to understand and solve the accelerated eutrophication problem until 1979 or later.

In May 1972, EPA began a 3-year $3.7 million nationwide lake survey to identify those bodies of water which are threatened by excessive fertilization that might respond to nutrient control measures. The study is expected to be completed in 1976. As of August 1973, sample data had been collected from 242 lakes in 10 States. Preliminary findings indicated that a majority are subject to accelerated eutrophication. (For more details see pp. 37 to 44, enc. A.)

Developing municipal pollution control technology

EPA spent about $140 million on municipal technology R&D during fiscal years 1966-73. We sent questionnaires to 100 large municipalities in this country to determine their most significant water pollution problems. The four problems most often cited were lack of or inadequate treatment facilities, combined sewers and storm runoff discharges, sludge handling and disposal, and nutrient removal.

Our review of EPA's research in the last three areas showed that, during fiscal years 1966-72, EPA applied a significant part of municipal technology funds to these problem areas, as follows.

	Amount (millions)
Combined sewers and storm runoff discharges	$43.1
Sludge handling and disposal	8.2
Nutrient removal	8.2
Total	$59.5

R&D emphasis has been on improving treatment processes to achieve higher rates of pollutant removal and on demonstrating existing technological alternatives. This has not, however, resulted in major technological breakthroughs or broad application of R&D results, primarily because of the high cost of implementation.

EPA spent about $14 million on projects to demonstrate storage as a means of controlling combined sewer discharges. This technique was used as early as 1934. Such demonstration, using conventional-type construction with minor modifications, was not, in our opinion, the most cost-effective use of limited R&D funds. R&D projects for other methods of control have been helpful in reducing the frequency of discharges but have not solved the problem completely.

EPA's R&D for sludge handling and disposal has been directed primarily toward obtaining a better understanding of sludge processes to improve their operational efficiency, and demonstrating existing technological alternatives. For example, EPA spent $1.8 million on five grants to demonstrate sludge disposal on land even though land disposal has been widely practiced. According to EPA, about 60 percent of all sludge is disposed of on land.

Our consultant who reviewed EPA's R&D efforts on sludge handling and disposal believed that the program's overall objectives, as well as the individual research plans, provided a framework in which the necessary R&D could be done. He pointed out, however, that inadequate funding by EPA and the lack of new ideas would prevent EPA from attaining these objectives quickly.

EPA concentrated its nutrient removal R&D program on demonstrating phosphorous removal using chemicals--techniques known for many years. The demonstrations showed that chemicals could remove large amounts of phosphorous, and many municipalities have used the methods demonstrated. EPA, in its effort to find ways to remove nitrogen, experienced technical problems and has not been able to demonstrate a method that can be widely used by municipalities. Also, fiscal year 1973 funding for nitrogen removal was reduced by EPA so much that no new projects could be undertaken. (See pp. 6 to 18, enc. B, for more details.)

Developing pollution control technology for industrial and other sources

EPA's AST program is directed toward solving water pollution problems resulting from industrial, transportation, agricultural, mining, oil and hazardous materials spills, and hydrologic[1] modification sources. The program supports EPA enforcement and standard-setting activities by developing and demonstrating new technology for (1) abating and controlling water pollution and (2) reducing the cost of waste treatment. During fiscal years 1966-73, EPA spent about $96 million for its AST program.

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[1] The science dealing with the properties, distribution, and circulation of water.

The AST program's major goal for the manufacturing industries has been to develop and demonstrate the practicality of closed cycle[1] (or closed loop) systems to control pollution. Its major goals in controlling pollution from other sources are to (1) develop and demonstrate improved management practices and system design modifications, to minimize or eliminate water pollution, and treatment systems to control, prevent, and abate water pollution and (2) provide data necessary to establish enforceable water quality standards.

EPA has developed and demonstrated new water pollution control technology that has industrywide application for some industries. For example, technology has been demonstrated to support closed cycle systems for the sugar-beet-processing and fiberglass-manufacturing industries. EPA officials identified 28 projects related to various industries that demonstrated, or when completed, were expected to demonstrate significant technological advances that could have industrywide application.

Some industrial associations supported EPA's views on the success and/or applicability of some of these projects. For example, 1 association reported that 5 of the projects were applicable to 50 to 100 of its members and that 50 of its members were using technology demonstrated by 1 project.

EPA estimated that from 5 to 20 percent of the technology had been developed to achieve zero discharge of pollutants from industrial sources. For other sources, the technology developed to achieve objectives ranged from zero to 70 percent.

On the basis of our review and our consultants' evaluations, we believe that EPA has made good progress in the AST areas. (See pp. 5 to 12 and 19 to 24, enc. C for more details.)

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[1] Closed cycle systems reuse waste water and do not discharge effluents into waterways.

WHAT NEEDS TO BE DONE TO ACHIEVE NATIONAL WATER POLLUTION CONTROL GOALS?

The Federal Water Pollution Control Act Amendments of 1972 established a national goal of eliminating the discharge of pollutants into navigable waters by 1985 and an interim goal of achieving water quality which provides for protecting and propagating fish, shellfish, and wildlife and which provides for recreation in and on the water by July 1, 1983. The amendments also declared that it is a national policy that a major R&D effort be made to develop the technology necessary to eliminate the discharge of pollutants into navigable waters, waters of the contiguous zone, and oceans.

To achieve these goals, the amendments provided for the establishment of water quality standards for all navigable waters and effluent limitations for point sources of pollution. The amendments also authorized the appropriation of $18 billion for grants to States and municipalities to help them construct publicly owned waste water treatment facilities.

In February 1973, EPA published its policies for implementing the 1972 amendments in a Water Strategy Paper. The paper, however, excluded an R&D strategy. EPA stated in this and other documents that the principal means of controlling point sources of pollution will be universal effluent limitations based on the best practicable or available control technology. However, if using this control technology does not achieve water quality standards, more stringent controls could be imposed. The paper added that water quality standards are to be the primary enforcement tool to control nonpoint sources of pollution and to regulate the dumping of wastes into the oceans. Thus, EPA plans to use a combination of water quality standards and effluent limitations to achieve national goals.

We did not analyze the total economic, social, and environmental effects of achieving or not achieving effluent limitations established by the 1972 amendments. To make this analysis, the amendments provided for a National Commission on Water Quality composed of 15 members--5 members of the Senate, 5 members of the House, and 5 members of the public appointed by the President. Appointment of the Commission members was completed in March 1973. The Commission is required to report the results of its study to the Congress by October 18, 1975.

Need for water quality criteria

The Federal Water Pollution Control Act Amendments of 1972 provide, in part, for (1) establishing water quality standards for all navigable waters, (2) regulating ocean dumping, (3) studying the effects of thermal discharges, and (4) conducting research and surveying the results of other scientific studies on the harmful effects of pollutants on the health or welfare of persons.

Until technology is developed to support sound effluent limitations that eliminate the discharge of pollutants into navigable waters, water quality criteria will play an important role in carrying out the provisions of the 1972 amendments.

Our consultants stated that, to fully understand the magnitude of water pollution and ways to control it, research is needed to determine how pollutants interact in the water and how such interactions affect aquatic ecosystems.

The National Academy of Sciences, in its 1973 draft report on "Research Needs in Water Quality Criteria," stated that scientific data in some areas was lacking, inadequate, or conflicting and restricted development of precise quantitative water quality criteria. The Academy identified six broad areas of research it believed should be considered high priorities:

1. Acute and cumulative effects of organic compounds on plant and animal life.
2. Effects of metals in water.
3. Development of bioaccumulation and concentration factors for many potentially harmful constituents of water.
4. Interaction of pollutants, especially metals and organic chemicals.
5. Ecosystems analysis--understanding the effects of pollutants on communities or organisms and the

impact of water quality on the total ecosystem structure and functions.

6. Relationship between microbial quality of water and human health.

Before fiscal year 1973, EPA had directed considerable effort to researching the effects of metals in water but had not directed much of its effort toward the other areas. In fiscal year 1973, EPA funded research projects in all of these areas.

The Department of Health, Education, and Welfare and EPA made a joint study on the health effects of environmental pollution and concluded in a January 1972 report to the Congress that more research was needed to (1) identify agents entering the environment, (2) assess their toxicity on man's biological systems, (3) develop new testing techniques to detect new agents before they are widely distributed, and (4) develop a scientific understanding of the effects combinations of chemicals have on health.

EPA has conducted little water pollution health-effects research, with funding ranging from $300,000 in 1969 to about $15,000 in 1972. EPA's funding for health-effects research in fiscal year 1973 was only about $97,000.

EPA is also performing health-effects research associated with drinking-water supplies and is currently studying diseases associated with water-based recreation. EPA funded about $1.2 million in fiscal year 1972 and $1.3 million in fiscal year 1973 for these studies.

The 1972 amendments required EPA to submit annual reports covering measures taken to implement the objectives of the Federal Water Pollution Control Act. In its first report, "Clean Water," dated May 31, 1973, EPA stated:

> "Major attention must be afforded health effects in the development of water quality standards. Accordingly, EPA has assigned priority attention to research activities in this problem area. Current research stresses the health effects of chemical and infectious contaminants in drinking and recreational water. During 1973 and 1974 emphasis

will be placed on an assessment of the toxic effects of trace minerals in the environment."

Freshwater criteria

Freshwater pollution problems are caused mainly by municipal, industrial, and other waste discharges. The interaction of these pollutants in an infinite number of combinations can change the level at which the pollutants are harmful to aquatic life. At the present time, the understanding of the interactions is poor.

EPA's research program provided little of the scientific knowledge necessary to determine the long-term effects or safe levels of most pollutants for aquatic life and, because of the vast number of potential pollutants and the large number of species of aquatic life, research in this area appears to be an almost endless effort. Further, much of EPA's freshwater research has been done in the laboratory and has not been validated and verified through field research. Natural environmental factors can alter the findings of laboratory-conducted research.

An EPA official estimated that, when EPA's current research is completed in about 1983, it will have carried out less than 1 percent of the research needed to develop freshwater quality criteria for all aquatic life in all navigable waters. This official also informed us that developing such criteria for all aquatic life with a 100-percent accuracy rate would require testing all stages of all species of aquatic life for each pollutant and combination of pollutants, in every type of water, and with field verification of all laboratory work. This effort would be astronomically costly.

However, this EPA official said such extensive research was not necessary and that EPA plans to develop freshwater quality criteria, to be used by States to set standards, by demonstrating the safe levels of 30 to 40 common pollutants for 3 species of fish and 3 species of fishfood organisms. (See pp. 13 to 20, enc. A, for more details.)

Marine waters criteria

The 1972 amendments to the Federal Water Pollution Control Act and the Marine Protection, Research, and Sanctuaries

Act of 1972 (86 Stat. 1052) authorized EPA to ban ocean dumping of certain materials and to establish a permit program.

In 1973, EPA started research on the acceptability of selected materials for marine disposal. Research is to be performed on individual pollutants in materials proposed for marine disposal. The results of this research will provide the scientific data needed for regulating ocean dumping and pollutant discharges into oceans.

The program director said that, as a result of funding reductions, EPA has been unable to perform the studies necessary to establish a scientific basis for ocean-dumping guidelines. He said that EPA's criteria for ocean dumping issued in May 1973 to meet legislative mandates were, for the most part, not based on adequate scientific research. EPA approved about $687,000 for research on ocean dumping in 1973 and estimated that it would spend about $12.6 million in fiscal years 1974-78.

Our consultants said that adequate technical data is not available for EPA to develop final guidelines on ocean disposal. One of our consultants stated that this research is important, not only to carry out the mandate of the Congress but also because relatively little research has been done on ocean dumping.

The National Academy of Sciences and the National Academy of Engineering, in their 1970 report on marine pollution problems, stated that a long-term research program is needed to gain a better understanding of the processes and interactions of wastes in the marine environment, to provide the basis needed to develop new waste management concepts and methods of pollution control. The Academies recommended that a 10-year, 2,660 man-year research program be initiated to provide the scientific knowledge to help solve our pollution problems in coastal areas. In terms of funding, this program would cost about $66.5 million on the basis of $25,000 per man-year.

EPA's program director for the fate of pollutants in marine waters program informed us in June 1973 that the program was in its initial stages of development. The director said no attempt had been made to determine the total research needs but that about 1,800 man-years of the 2,660 man-years of research identified by the Academies would be within the scope of his program.

During fiscal years 1969-72, most of the research effort to determine the fate of pollutants was directed toward developing predictive techniques that described the physical movement and dispersion of pollutants discharged into marine waters. EPA established standard procedures for predicting the behavior of various industrial and municipal wastes from ocean outfalls (submerged pipelines) and prepared a users' guide that State officials can use for analyzing pipeline discharges. The following drawings show four possible patterns of discharged wastes these procedures can predict.

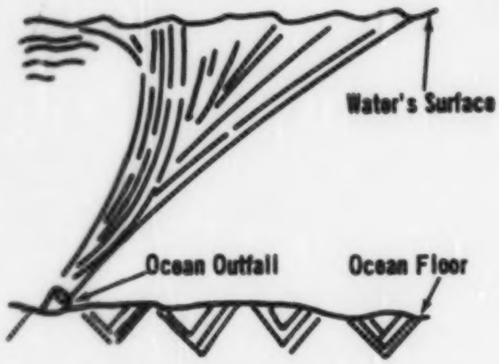
Through the use of data on pipe size and force of flow, this model is capable of predicting the direction and height of a waste pattern along with the waste concentration at various locations in the pattern. This data, in combination with scientific information on the effects of the various pollutants on the marine environment, provides the scientific data needed to make valid decisions on proposed waste discharges into the marine environment.

EPA, however, did little research to develop predictive techniques for chemical or biological interactions and transformations of wastes, sludge, and debris discharged into the sea.

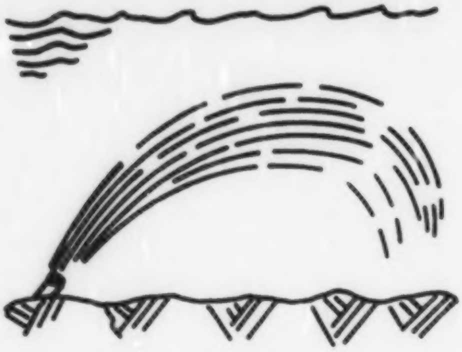
One of our consultants reviewed EPA's fate of pollutants research plans and objectives for fiscal year 1973 and concluded that, collectively, they represented the most significant marine research needs but addressed only a small portion of the needs. He said that it is important that EPA plan to verify the predictive models being developed because there is disagreement among the scientific community and others as to their validity.

EPA's research on the harmful effects of pollutants on the marine environment is the responsibility of its National Marine Quality Laboratory at West Kingston, Rhode Island. The laboratory has not completed a major in-house research objective since starting research in 1967. Laboratory officials were unable to indicate any accomplishments other than the laboratory's contribution to the development of water quality criteria.

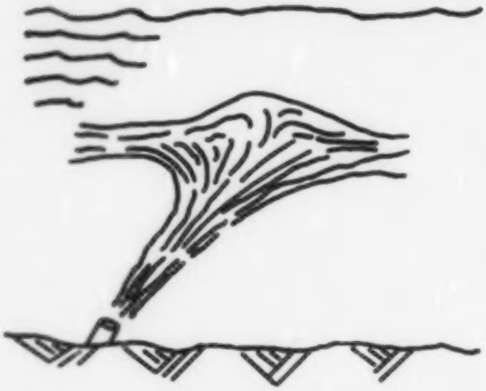
FOUR POSSIBLE WASTE DISCHARGE PATTERNS WHICH CAN BE PREDICTED


Water's Surface
Ocean Outfall
Ocean Floor

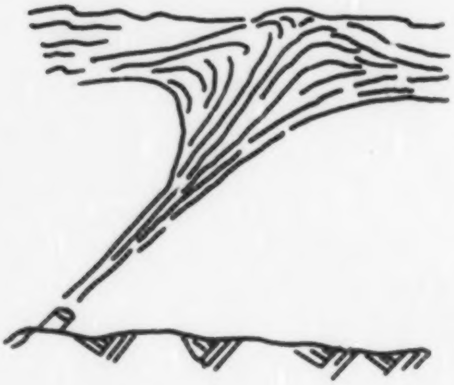
DISCHARGED WASTES RISE TO WATER'S SURFACE



DISCHARGED WASTES RISE, NOT REACHING THE SURFACE, AND THEN DESCEND TO LOWER DEPTH



DISCHARGED WASTES RISE AND REACH POINT OF EQUILIBRIUM BELOW WATER'S SURFACE



DISCHARGED WASTES RISE TO SURFACE BUT LATER SETTLE AT POINT OF EQUILIBRIUM BELOW THE WATER'S SURFACE

The assistant laboratory director informed us that in the earlier years the laboratory was involved in (1) acquiring background knowledge and (2) developing facilities. He said that earlier research was broadly directed and had ill-defined end-products but that it had slowly evolved into more definite work plans with specific end-products. EPA research officials estimated that, as of April 1973, they had completed about 5 percent of the ecological research, less than 1 percent of the toxicological research, and about 15 percent of the bioassay research needed to develop marine water quality criteria. (See pp. 20 to 29, enc. A, for more details.)

Thermal discharges criteria

According to a National Water Commission report to the President and the Congress issued in July 1973, the effects of thermal pollution resulting from energy production was one of the three highest priority areas needing research. Our consultants agreed that it was important to do more research on the effects of thermal discharges on man and his environment. However, research on thermal discharges has been delayed because of limited funding. The 1972 amendments authorized the appropriation of $10 million in each of fiscal years 1973 and 1974 for researching the effects and methods of controlling thermal discharges.

EPA's research laboratory in Duluth, Minnesota, is responsible for determining the effects of thermal discharges on fish and food organisms. The following photograph shows some of the biological effects of thermal waste water discharges from power-plants that do not use cooling techniques. The program director at the Duluth laboratory informed us in January 1973 that the laboratory had published the results of its research during fiscal years 1969-72 in various scientific journals. He further stated that the laboratory had completed about 25 percent of its planned research and the laboratory and other research groups had been responsible for satisfying 10 to 20 percent of the Nation's existing thermal pollution effects research needs.

According to potential research users a major factor limiting EPA's thermal effects research was that the research had been done in a laboratory environment or at sites having considerably different environmental conditions than the

AFTER EXPOSURE TO UNUSUALLY HIGH THERMAL POWERPLANT DISCHARGES, LARGE NUMBERS OF DEAD PISTOL SHRIMP, BOTTOM-DWELLING FISH, SPIDER CRABS, BLUE CRABS, SMALL CLAMS, SNAILS, SPONGES, AND BAY CORALS SIMILAR TO THOSE PICTURED HERE WERE FOUND. (EPA PHOTOGRAPH) bodies of water in the users' regions or States. The potential users believed that EPA's program should be redirected toward site-oriented research. One potential user informed us that results from site-oriented research could more logically be used as a basis for making operational decisions on such matters as State water temperature standards, discharge permit applications, and enforcement actions.

We believe that EPA's thermal research program should include both field and laboratory research, with more immediate emphasis on specific site studies for setting water quality standards. (See pp. 30 to 35, enc. A, for more details.)

Need for better understanding of thermal pollution control problems

EPA's laboratory in Corvallis, Oregon, was responsible for research into the engineering aspects of thermal discharges and for developing environmental systems for managing heated discharges safely. As of April 1973, EPA's research to develop methods of thermal pollution control had been directed to one major research area: physical fluid prediction. Little research had been performed on four other research areas: (1) behavior of cooling tower plumes in the atmosphere, (2) chemical aspects of heat in water, (3) biological aspects of heat in water, and (4) field verification of predictive models.

The program director's overall assessment was that over 50 percent of the Nation's existing thermal water pollution problems had been researched. He also expressed the opinion, however, that, because thermal discharges will increase because of greater use of nuclear power plants, EPA has not yet begun to solve the thermal pollution problems which will be present in the Nation's waters 20 years from now. (See pp. 36 and 37, enc. A, for more details.)

Need for R&D to support lake restoration programs

The 1972 amendments authorize appropriations of $300 million during fiscal years 1973-75 for grants to help the States carry out pollution control and restoration programs on lakes. As of December 1973, funds had not been appropriated for these programs. EPA plans to begin the programs during fiscal year 1974.

EPA program officials told us that none of the techniques for point source nutrient control, in-water nutrient reduction, or nonconventional lake restoration methods had been fully demonstrated and evaluated as of July 1973 and that they did not expect to complete these or other evaluations required to fully satisfy research needs in this area until after fiscal year 1979. The program director estimated that it would cost $50 million to develop and demonstrate lake restoration technology. Further, EPA's lake survey study to identify bodies of water threatened by accelerated eutrophication that might respond to nutrient control measures is not expected to be completed until 1976.

To support its lake restoration grant program, EPA needs to complete its lake survey and evaluate the feasibility of lake restoration techniques being developed and demonstrated so that it will have sufficient information to:

--Identify those lakes threatened by accelerated eutrophication that might respond to nutrient control measures.

--Fully evaluate the probability of the success of lake restoration techniques that might be proposed by States requesting grants under the lake restoration program.

As EPA completes its lake survey and begins to demonstrate feasible lake restoration techniques, it should establish a sound basis for and be selective in awarding lake restoration grants to States to insure the most effective use of its resources. (See pp. 37 to 44, enc. A, for more details.)

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In a May 1973 report, EPA stated that processes-and-effects research, together with control technology, will be important elements in its water quality control program and that attention will be directed toward researching

--the effects of water pollution, to develop criteria to be used in setting water quality standards for fresh and marine waters;

--health effects, to develop water quality standards for drinking and recreational waters; and

--the effects and methods of controlling thermal discharges.

We believe that these research areas are of high priority. As EPA develops and uses sound effluent limitations in its regulatory activities, the need for some processes-and-effects research may diminish.

Minimizing the cost of municipal water pollution control: a challenge to EPA

One of the primary objectives of the municipal technology program should be to find ways to minimize the cost of municipal water pollution control, either by modifying existing technology or by developing new techniques. Two benefits can be obtained by minimizing the cost of control processes: (1) reduced costs would enable municipalities to more easily finance and operate control facilities, which should increase the probability of earlier construction and (2) since the Federal Government provides 75 percent of the cost to construct municipal waste treatment plants, reduced costs would permit a wider distribution of Federal funds to construct more treatment plants, which should result in greater progress toward improving water quality.

EPA has generally applied its municipal R&D resources to solve municipalities' major pollution problems, e.g., combined sewer discharges, sludge handling and disposal, and nutrient removal. Much of EPA's municipal technology R&D program has been directed toward developing and demonstrating technology that would achieve higher treatment or removal levels; however, implementing the technology is costly.

On November 21, 1972, we issued a report to the Congress entitled "Need to Improve Administration of the Water Pollution Research, Development and Demonstration Program" (B-166506). In the report we stated that many demonstration grants had been awarded for constructing and operating full-scale conventional waste treatment facilities which did not demonstrate new or improved waste treatment processes but rather modified or extended conventional processes. Our current review showed that this situation has not changed.

Section 207 of the act authorizes the appropriation of $18 billion for fiscal years 1973-75 to help States and municipalities construct such facilities. In 1972, before enactment of the amendments, EPA estimated that it would cost about $153.8 billion ($71.5 billion in capital costs and $82.3 billion in operating costs) for municipalities to achieve zero discharge by 1981. The magnitude of the estimated cost to achieve zero discharge underlines the need to minimize the cost of pollution control processes.

EPA officials told us that cost effectiveness and cost reduction are inherent goals in engineering activities and that, therefore, it is difficult to identify these efforts in the municipal technology program. EPA officials in charge of portions of this program pointed out that the need for cost reduction was recognized and was being considered in the program. They stated that the program was directed at developing treatment processes which led to higher pollutant removal levels. These treatment processes frequently were more costly than existing processes which removed less pollutants.

We recognize that achieving higher pollutant removal levels will probably increase the total cost of municipal water pollution control. While cost reductions may be inherent in engineering activities, we believe that such efforts should be made visible and be a stated prime objective of the municipal technology program. Even relatively small percentage savings, applied broadly, would result in a wider distribution of Federal funds to construct more treatment plants, which should result in greater progress toward improving the quality of the water. (See enc. B, pp. 9 to 18 and 32 to 43.)

Funding of municipal technology development program

Most States and municipalities rely on the Federal Government for financial assistance for constructing waste treatment facilities and for developing technology necessary to solve municipal water pollution problems, which, in larger municipalities, are particularly complex and costly.

EPA funding for municipal technology R&D has decreased, while funding for its construction grant program has significantly increased. The following schedule shows the amount of funds provided for construction grants and municipal technology R&D during fiscal years 1967-72 and the percent of R&D funds in relation to construction grant funds.

EPA Funding

	Construction grants	Municipal technology R&D	Percent
	(millions)		
1967	$ 150	$26.2	17.5
1968	203	25.2	12.4
1969	214	24.3	11.3
1970	800	18.5	2.3
1971	997	19.1	1.9
1972	2,000	12.8	.6

In fiscal year 1973, EPA obligated about $3 billion for construction grants but funded its municipal technology R&D at only $9.5 million, or about 0.3 percent of the funding provided for construction grants. In comparison, the Department of Transportation's Urban Mass Transportation Administration, which has $1 billion for its annual capital grants program, is spending about 8 percent, or $80 million, on research.

EPA funding of municipal technology R&D can also be compared to the national average for industry which is about 4 percent of net sales for research. Some major industries exceed the national average as can be seen by the following data for 1970, the last year for which figures were available.

Industry	Funds for R&D as a percent of net sales
Aircraft and missiles	18.3
Electrical equipment and communication	7.5
Professional and scientific instruments	5.9
Machinery	4.2
Chemicals and allied products	4.1

EPA officials responsible for developing research plans estimated the following funding needs for fiscal years 1973-78 to meet municipal technology development objectives.

Fiscal year	Estimated funds needed
	(millions)
1973	$ 34.5
1974	42.9
1975	50.7
1976	43.5
1977	27.9
1978	25.4
Total	$224.9

Only $9.5 million, or 28 percent, of the $34.5 million requested by EPA program directors was funded by EPA in fiscal year 1973. At the present funding level, it would take about 24 years to carry out the research program planned above.

Technology needed to control pollution from industrial and nonpoint sources

The 1972 amendments provide for a major R&D effort to develop technology necessary to eliminate the discharge of pollutants into navigable waters, waters of the contiguous zone, and oceans. The amendments provide for industry's application of:

--The best practicable control technology currently available, which AST officials have defined as removing 85 percent of the pollution, by July 1, 1977.

--The best available technology economically achievable, which AST officials have defined as removing 95 percent of the pollution, by July 1, 1983.[1]

The amendments also establish a goal of zero discharge by 1985. AST officials have defined this as being a discharge comparable in all water quality aspects with the receiving body of water, or no discharge.[2]

The requirements for best practicable control technology and best available technology apply only to point sources of pollutants, whereas the zero discharge goal applies to all sources of pollutants. Before enactment of the 1972 amendments, EPA had established agency R&D goals to achieve interim levels of 85- and 95-percent pollution removal and ultimately, zero discharge for industrial point sources of pollution.

We asked AST officials for an estimate of the technology development goals that had been achieved (technology demonstrated to be both technically and economically feasible) for AST areas in relation to overall legislative and agency goals.

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[1] These are interim definitions of the AST Branch. EPA is currently determining the level of technology that will satisfy these statutory terms and is formally defining them as they relate to each type of industry.

[2] This is an interim definition of the AST Branch. EPA is currently determining the level of technology that will satisfy this statutory term and is formally defining it as it relates to each type of industry.

The estimates furnished were based primarily on AST Branch officials' judgment. Because EPA officials were not fully aware of the R&D efforts of others in the AST area, they gave little consideration to what other agencies, private industry, or the States had done, except in those instances where EPA participated in funding projects conducted by others. EPA officials emphasized that many active projects, when completed, would add to the levels of technology already achieved.

The following schedule shows EPA's estimate of the percentages of technology developed as of June 30, 1973, for controlling water pollution from industrial sources.

	Percent of established goals attained		
Program area	Best practicable control technology (note a)	Best available technology	Zero discharge
Heavy industrial sources:			
Metal and metal products	75	25	5
Chemical and allied products	60	20	5
Power production	60	20	10
Petroleum and coal products	95	35	20
Machinery and transportation equipment manufacturing	75	25	10
Textile mill products	75	25	5
Rubber and plastic	80	25	10
Joint industrial-municipal wastes	75	25	16
Thermal pollution technology	80	40	20
Light industrial sources:			
Paper and allied products	90	25	10
Food and kindred products	90	20	5
Stone, clay, and glass products	75	25	15
Lumber and wood products	90	25	10
Miscellaneous industrial sources	70	25	10

[a] It was estimated that in 1967, when EPA's industrial program started, about 10 percent of the technology for achieving 85-percent pollution removal was available.

The schedule shows that significant results have been achieved toward developing the best practicable control technology. However, much remains to be developed and demonstrated to achieve the best available technology economically achievable and the 1985 goal of zero discharge.

We sent questionnaires to several national industrial associations and asked them to comment on EPA's estimate of water pollution control or removal technology development that had been achieved, but not necessarily implemented, in the industrial areas as of June 30, 1973.

The 16 associations responding to this question generally believed that EPA was optimistic about the level of technology development achieved. Some believed that:

--Estimates were based on limited single-plant demonstrations or pilot programs that were often conducted at new and larger plants which were not representative of the industry.

--Technology developed for one industry cannot necessarily be applied to another.

The act, as amended, does not mention control objectives for nonpoint sources of pollution, other than stating that zero discharge is the national goal by 1985. EPA officials said zero discharge is not economically or technically feasible for all nonpoint sources of pollution. For such sources, EPA officials established what they considered to be achievable control objectives, ranging from zero discharge for watercraft wastes and animal feedlots to improved management practices or process modifications to minimize pollution from other nonpoint sources.

The following table shows EPA's estimate of the percentages of technology development goals attained for nonpoint sources of pollution as of June 30, 1973.

Area	Percent of established goals attained
Transportation sources:	
Recreation	15
Watercraft wastes	30
Agricultural sources:	
Forestry and logging	20
Agricultural runoff	30
Irrigation return flows	30
Animal feedlots	35
Natural runoff	5
Aquaculture	40
Sludge disposal	50
Mining sources:	
Acid drainage:	
Basic research	90
Treatment	70
Prevention--surface mines	50
Prevention--underground mines	10
Prevention--new mining methods	10
Oil production	10
Oil shale	10
Phosphate mining	20
Other mining sources	10
Oil and hazardous materials spills:	
Hazardous material spills	10
Oil spills	20
Hydrologic modification:	
Construction	40
Dredging	15
Water resources development	-

The two preceding tables show that much remains to be accomplished to achieve legislative and agency pollution control goals for both point and nonpoint sources. At our request, AST branch officials furnished us with the following estimates of the additional funding required to achieve the goals for AST areas.

Area	Estimated funding required
	(millions)
Heavy industrial	$151.8
Light industrial	67.3
Transportation	5.0
Agricultural	76.5
Mining	117.0
Oil and hazardous material spills	117.0
Hydrologic modification	8.0
Total	$542.6

AST officials told us that, on the basis of past and current funding levels, totaling $96 million during fiscal years 1966-73, they did not expect to achieve their 1977, 1983, or 1985 goals. These officials estimated that about $45 million was needed annually for an effective AST program.

If EPA's estimate of about $543 million in additional funding is reasonable and if EPA's current funding levels remain the same for the AST area, it could take more than 45 years to achieve those goals. Further, once the technology is developed and demonstrated, it could take anywhere from 5 to 7 years before it is implemented. (See pp. 19 to 24, enc. C.)

Need for a water pollution R&D strategy

We found that EPA has not had an agency R&D plan setting forth goals, objectives, and priorities since it was formed in December 1970. Guidance provided to agency R&D planners is broad and in the form of legislative requirements and budgetary constraints. Before the enactment of the 1972 amendments, the Administrator established a task force to determine the impact the amendments would have on EPA. In its report, the task force stated that "EPA has not adequately assessed R&D needs; has not precisely phased or quantified general objectives, and has not produced a delineated structure of program and project priorities."

The Administrator recently issued a water strategy paper to implement the requirements of the 1972 amendments and provide guidance to its headquarters and regional personnel and to the States in setting annual objectives, allocating resources, and regularly reporting on the achievement of these objectives. The strategy, which focuses on areas of Federal-State program activity, does not include the R&D activities to be performed under the act. Efforts have been initiated by EPA to expand the strategy to include R&D activities.

Because proposed projects far exceed current resources we believe that a systematic method, using established criteria against stated goals and objectives, should be used in selecting research projects. An expanded strategy should provide program managers with guidance as to national research goals, objectives, and priorities. Thus, program managers would be provided with criteria for making decisions as to R&D priorities, alternative approaches, and levels of efforts, as well as for allocating resources among the various R&D areas.

EPA is envisioned as a point of central coordination and cognizance for research related to its policy, standard-setting, and regulatory roles. We believe that an expanded strategy would enhance such coordination. EPA states in its water strategy paper that, "As a public statement of EPA's intentions for a decade of water pollution control, it (water strategy paper) will also serve as a means of encouraging public comment and public participation." (In this regard, EPA should fully utilize the results of research conducted under a national water pollution R&D plan, as discussed in chapter 4, to fulfill its R&D objective.)

Section 516 of the amendments requires EPA to submit an annual and a biennial report to the Congress containing, in part, a summary of the measures taken toward implementing the objectives of the act, including the results achieved in the field of water pollution control research and a detailed estimate of the cost of carrying out the provisions of the act. In this regard, EPA should provide the Congress with its R&D strategy and an estimate of the funding necessary to fulfill its requirements.

Opportunity for improving EPA's management of its water pollution R&D effort

The primary objective of EPA's R&D program is to support its regulatory and financial assistance programs. We found that, to be more responsive to the R&D needs of these programs, EPA needs to

- --improve the implementation of its R&D program planning system and fully document the basis for selecting and assigning priorities to R&D projects,
- --establish procedures for revising water quality criteria on a more frequent basis as new valid research results become available,
- --publish the results of its processes-and-effects research more promptly and make such data available to EPA regional offices, State agencies, and other potential users, and
- --insure that the AST program better supports the R&D needs of enforcement and standard-setting activities.

We found also that, because EPA had not defined its position on certain water pollution problems, OR&D could not decide what research, if any, should be undertaken. EPA's R&D effort concerning mercury sedimentation and stabilization ponds are two research program areas whose progress has been hindered because EPA lacked a clear policy.

Problems in implementing the EPA planning system

In March 1972, EPA established a new R&D planning system to respond to the environmental research needs of the agency. Our review of this system's operation in fiscal year 1973, as it related to water pollution R&D, showed that there were problems in planning R&D programs because the system was new, and established procedures were not followed. As a result, the effectiveness of the water pollution R&D programs was weakened. The municipal technology program manager stated that the fiscal year 1973 planning system was a failure. He stated that priorities were not set for the individual tasks in the plans, the plans did not show a logical step-by-step progression to meet an objective, and it was impossible to fund complete plans within the allotted funding.

EPA did not fully address the R&D needs of its operating programs--One of the major features of EPA's R&D planning system is soliciting research needs from EPA program offices, EPA regional offices, R&D program managers, and State and local regulatory agencies. In many cases, EPA did not address the research needs of these groups or delayed significantly in providing requested R&D results.

The EPA planning system provides feedback to inform requestors of the action taken on their requests for R&D. OR&D records indicated that 88 percent of the research needs submitted by EPA regional offices were adequately met. However, officials at four regional offices we visited prepared detailed analyses of the program's responsiveness to their top-priority R&D need requests. Their analyses showed that their needs, to a large extent, were not being addressed. For example, in a November 1972 memorandum, EPA region I stated, "We judge that our ten highest-priority needs are 40 percent understood and responded to."

Regional officials stated that, for the most part, the approved plans were influenced by a strong tendency to continue active projects or to concentrate on specific areas of the research plans. In their opinion, needs were being shown as fulfilled since the research plans pertained to the general area of the problem, but in actuality the needs would not be met.

Arrangements for funding R&D work plans hindered program accomplishments--EPA's R&D program planning manual states that (1) the R&D work plan is the basic unit for program planning decisions, (2) all tasks within a plan are considered essential for its successful accomplishment, and

(3) a work plan is approved as a whole, never in part. Our review indicated that achieving many high-priority R&D objectives would be significantly delayed because too many plans were partially funded with available resources, and therefore, many plans with the highest priority were not funded sufficiently to meet assigned objectives.

Our analysis of the approved fiscal year 1973 research plans for those R&D programs included in our review showed that approximately 60 percent of the plans had received less than half the funds considered necessary by the program directors.

EPA established a list of national priorities for AST areas and ranked the problems to be solved in accordance with their severity. However, EPA allocated funds to all problem areas without regard for priority status. As a result high-priority problems were inadequately funded on a year-to-year basis, even though the solution of those problems would have had the greatest impact on improving the quality of the water.

EPA officials acknowledged that AST program resources had been fragmented among all problem areas, which limited the effectiveness of their efforts. The officials said they anticipated a certain level of funding and they therefore hired personnel with expertise in many different areas when the program was initiated. When less funds were received, they tried to maintain at least a minimum program in all areas instead of reducing their staff.

Of the 47 municipal technology work plans funded in fiscal year 1973, 44 were funded below the levels requested in the initial plans. Furthermore, funding for 29 of the approved work plans was reduced by at least 70 percent of that considered necessary by program directors to meet specific R&D objectives within the planned time frame.

EPA officials told us work plans were inadequately funded because a certain amount of funds was always required to keep staff and to salvage existing research, regardless of priority. One program official said that he allocated his funds in the following order: (1) to employees' salaries, (2) to purchase or support facilities required for existing projects, (3) to ongoing projects requiring additional funding, and (4) to new projects.

The basis for selecting and assigning priorities to R&D projects was not sufficiently documented--Throughout the R&D planning process, a series of decisions are made which determine the research needs and proposed R&D projects that are to be formally entered into the planning system for funding consideration. OR&D officials have made those decisions primarily on the basis of professional judgment and experience and have not sufficiently documented their rationale.

Within the municipal technology area, field officials prepared plans without funding constraints and proposed research plans requiring $34.5 million. The Municipal Pollution Control Division's budget for fiscal year 1973 was $9.5 million. Our review showed that the basis for plan approval, funding allocation, and task selection was primarily the professional judgments of the Municipal Pollution Control Division and other OR&D headquarters officials. EPA did not document, and we were unable to determine, the criteria used in making the decisions.

We believe that, in selecting specific research projects to accomplish stated goals, research planners should fully document and provide visibility for the rationale used for the decisions made. They should evaluate the projects on the basis of certain universal criteria, such as:

--Utility: What will the project contribute to organizational goals?

--Probability of success: Is the project likely to achieve the desired objective?

--Time: When are results needed and how long will the project take to complete?

--Cross support: How much will project results contribute to the success of other projects?

--Urgency: How urgently is a solution needed?

Such criteria could be used to establish project priorities; those having the highest priority would be expected to have the highest probability of being funded. Under this approach, value judgments would not be eliminated, but the process would be structured, visible, and explicit.

We were informed that OR&D officials do consider these types of criteria in deciding the relative priorities of proposed R&D projects and which projects are to be considered for funding. We believe, however, that appropriately documenting the basis for such decisions would provide top EPA management officials with a means of readily assessing the effectiveness of the OR&D planning process.

OR&D officials told us in September 1973 that certain changes were being made to improve the R&D planning system and its implementation. For example, new procedures have been instituted which provide for developing and reviewing the research plan in two stages. They stated that the purpose was to try and obtain more input from the operating groups and the regions before making final decisions on the research projects to be funded.

OR&D officials informed us also that they agreed that the decisionmaking process needs to be adequately documented and that they were in the process of establishing procedures to require such documentation.

Updated water quality criteria not available when needed

EPA informed the Congress in April 1971 that water quality criteria developed in 1968 by the Department of the Interior's National Technical Advisory Committee had to be updated to meet the requirements for setting water standards contained in proposed amendments to the Federal Water Pollution Control Act. The amendments were enacted in October 1972 and provided the following timetable for States to revise existing interstate and intrastate standards and to establish new intrastate standards.

Existing interstate standards--April 18, 1973
Existing intrastate standards--June 18, 1973
New intrastate standards--October 18, 1973

EPA contracted with the National Academy of Sciences in April 1971 to update the 1968 EPA "Water Quality Criteria" report referred to as the "green book." EPA agreed to provide the Academy with scientific data from its research efforts.

EPA required the Academy to submit a draft report by December 1971 and a final report by May 1972. The Academy submitted an initial draft to EPA in December 1971. Due to EPA's delays in approving the report, the final draft was not available until July 1972. EPA officials informed us that the draft was delayed for about 6 months while they waited for other agencies to review it. EPA officials told us EPA approved the final report in February 1973 and that it was to be published and distributed by December 1973. The report, therefore, was not available as planned to implement the water quality standards required by the Federal Water Pollution Control Act Amendments of 1972. EPA informed its regional administrators in November 1972 that review and revision of water quality standards would be a priority task in implementing the 1972 amendments and that, as a matter of policy, the 1968 water quality criteria should be used in reviewing and revising water quality standards.

The Academy, in its draft report, pointed out that it did more than just revise the 1968 criteria. Its new criteria was nearly four times longer and discussed many new subjects in detail, i.e., toxic or potentially toxic substances not included in the green book. The draft report also expanded data available from recent research activities and showed greater awareness of how various characteristics of water affect its quality and use.

Updating existing water quality criteria to incorporate new scientific data is a long-term, time-consuming task. We believe that, instead of revising the criteria every 5 years or so, procedures should be adopted to revise the criteria on a more frequent basis as new valid research results become available. This would transfer new scientific data faster to potential users for use in setting future water quality standards and taking enforcement actions. For example, a looseleaf criteria manual could be published and maintained in which changes could be made by simply replacing pages. (See pp. 52 to 54, enc. A.)

Delays in publishing processes-and-effects research results

Data from many of EPA's research projects was not available to potential users when needed because results were not published on time. In the processes-and-effects research area 204 projects were completed during fiscal years 1969-72. As of December 1972, reports on 112 projects had not been published for a variety of reasons, including the lack of funds.

Although research results may be informally released before publication, we were advised that researchers are reluctant to do so for fear that other researchers might "steal" their findings and publish the results themselves.

Because the States and EPA standard-setting and enforcement personnel need scientific information as it becomes available, EPA should publish the results of its research more promptly. (See pp. 48 to 50, enc. A.)

Needs of enforcement and standard-setting activities not always met

Although EPA has made good progress in the AST area, we found that the AST program had not fully responded to the needs of EPA's regulatory and standard-setting activities because of inadequate coordination between OR&D and the offices involved in such activities. Further, the responsiveness to future needs may be limited because the AST program is not being funded at a level high enough to enable prompt development and demonstration of technology.

Officials of EPA's Office of Technical Analysis, which is responsible for insuring the adequacy and validity of (1) economic, scientific, and technical data and (2) evidence supporting the development of enforcement policy, individual enforcement actions, and other legal proceedings, stated that the program had not been responsive to their needs. They told us that coordination between enforcement and research personnel was lacking and that, until recently, they had no formal input into the planning and priorities of the program. They pointed out, however, that they had been able to use the expertise of AST personnel in enforcement actions.

The Office of Technical Analysis submitted a formal list of 11 long-term needs to the Office of Research and Development for funding in fiscal year 1974. Only four of the needs were written up into work plans, and only two work plans were funded. Officials of the Office of Technical Analysis advised us that the two work plans which were funded did not appear to reflect an understanding of their requests. They told us the failure to prepare work plans and to fund all of their needs resulted because OR&D misunderstood these needs.

EPA's Effluent Guidelines Division, Office of Air and Water Programs, establishes effluent standards and guidelines for industrial sources of pollution and furnishes technical assistance in enforcement actions. An official of that office told us that, in the past, extensive use had been made of AST project data. He said, however, that he did not believe the industrial program was going to be responsive to his office's future needs. According to him, even though the Federal Water Pollution Control Act Amendments of 1972 state that a major R&D effort will be undertaken to develop technology necessary to eliminate the discharge of pollutants, the industrial portion of the program was not being supported or funded by EPA at a level sufficient to develop, when needed, the technology on which to base effluent standards.

An official of EPA's Office of Permit Programs, which is responsible for developing plans and providing policy direction for implementing the National Pollutant Discharge Elimination System, told us that his office had not had any input into planning the AST program. He said that the projects funded under the program had little or no value for his office. In his opinion, many of the projects funded were directed toward unique situations at individual plants and had limited industrywide application.

We believe that the AST program would be more effective if program officials directed their efforts more toward the R&D needs of enforcement and standard-setting activities.

R&D in certain areas hindered because of indefinite policy

Sediments in the Nation's waterways contain mercury deposits, even though most discharges of mercury have been stopped. These deposits can change into highly toxic methyl mercury which can enter the aquatic food chain. EPA was aware of this problem in 1970 and stated that methodology needed to be developed to remove, stabilize, or inactivate these mercury deposits.

In 1971, because of the mercury scare of 1970, EPA awarded six contracts totaling $400,000 to several organizations to develop the technology to remove or neutralize mercury. The contracts were completed in fiscal year 1972, and the program director stated that a major effort should be directed toward evaluating the technology developed and testing it under field conditions. The program manager, however, stated that not a single viable method had been developed or demonstrated under these contracts.

An EPA enforcement official stated that research was needed to determine the disposition of mercury deposits in the sediment to support enforcement actions. The R&D program director for this area requested $421,000 for fiscal year 1973 and $1.3 million for the next 5 years to continue research on the problem. However, only $12,500 was allocated in fiscal year 1973. An EPA OR&D headquarters official stated that the low funding level was due partly to the fact that the public was no longer concerned about mercury deposits.

Although the 1972 amendments require EPA to identify the location of in-place pollutants, specifically toxic pollutants, in harbors and navigable waterways and authorize EPA to arrange for their removal and disposal, the R&D program manager stated that the problem of mercury in sediments has not been sufficiently defined to continue research for developing technology and that R&D would be discontinued after fiscal year 1973.

Stabilization ponds or lagoons are large impoundments constructed to hold raw sewage for removal of solids and oxygen-consuming matter by a natural process. Before 1973, a conflict existed as to whether the ponds met EPA's secondary treatment requirement of 85 percent biochemical oxygen demand (BOD) removal. EPA's Office of Water Programs believed that R&D was needed to find ways to upgrade ponds because pond treatment did not meet removal requirements.

Further, an EPA official stated that stabilization ponds would not meet the new EPA definition of secondary treatment. However, OR&D officials stated that the ponds came very close to fulfilling the requirement and that research was not needed.

The Office of Water Programs gave this area a high priority, but R&D funding was not very extensive. Research on stabilization ponds began in fiscal year 1967, but, through fiscal year 1972, only one project had been funded for $67,000. Although stabilization ponds research was the third highest priority in EPA's 1973 municipal technology research program, only $113,500 was allocated to that research area during the initial program funding cycle as compared to $500,000 requested.

EPA informed us in October 1973 that it now has determined that, with proper design and operation, stabilization ponds can meet secondary treatment requirements and that, as a result, a major R&D effort is underway to improve stabilization pond systems. EPA stated that approximately $317,000 has been allocated for this research and there are three R&D projects in process. (See pp. 19 to 23, enc. B.)

CONCLUSIONS

The Federal Government is primarily responsible for researching the sources, fate, and effects of water pollutants to develop water quality criteria and establish water quality standards. In addition, it does technology development research to find new or improved methods and processes to control point and nonpoint sources of pollution that degrade the quality of the Nation's waterways.

Our study has shown that Federal R&D programs have contributed to the progress that has been made in improving the quality of some of our waterways; however, much remains to be done to achieve the goals of the Federal Water Pollution Control Act Amendments of 1972. There is a need for continuing processes-and-effects research to

--develop water quality criteria to establish water quality standards,

--regulate ocean dumping,

--determine the harmful effects of pollutants on the health and welfare of man,

--study the effects and obtain a better understanding of controlling thermal discharges, and

--identify lakes that might respond to nutrient control measures and evaluate the feasibility of lake restoration techniques being developed and demonstrated to support the lake restoration grant program.

Some researchers believe that processes-and-effects research will be a never-ending effort. We believe, however, that over the next several years, EPA should direct its processes-and-effects research toward obtaining the scientific knowledge most needed to achieve the Nation's goals and to implement EPA's policies as outlined in its Water Strategy Paper. This research should be coordinated with the development of effluent limitations based on advances made in water pollution control technology. As EPA develops and uses sound effluent limitations in its regulatory activities, the need for some processes-and-effects research may diminish.

EPA also needs to consider new and innovative approaches to find ways to minimize the cost of municipal water pollution control. Huge sums of money--Federal, State, and municipal--are expected to be spent on constructing and operating municipal treatment plants. Reduced costs for such purposes would enable municipalities to more easily finance the treatment facilities and thereby increase the probability of earlier construction. In addition, reduced costs would permit a wider distribution of Federal funds to construct more treatment plants which should result in greater progress toward improving the quality of water.

Technology development over the next few years will have a direct bearing on EPA's effluent limitations. Results in achieving the best practicable control technology for industrial sources of pollution have been significant, but much technology remains to be developed and demonstrated to achieve the best available technology economically achievable and zero discharge by 1985. Even more remains to be accomplished for nonpoint sources of pollution in the AST area, to achieve the legislative goals.

We believe that EPA should determine the Federal water pollution R&D needed to meet legislative and agency goals and should develop a strategy to meet these goals. This strategy should provide program managers with guidance as to national R&D goals, objectives, priorities, and funding requirements.

EPA, in developing and implementing an R&D strategy, should fully use the results of research conducted under a national water pollution R&D plan. The national plan should provide for an integrated, systematic, and comprehensive approach using the water pollution R&D expertise of all Federal agencies and non-Federal organizations and the States, industry, and universities, and should be revised and updated frequently. After the plan has been developed, EPA should actively seek the cooperation of other Federal agencies and non-Federal researchers in implementing it. (See ch. 4.)

We found that Federal agencies' systems for collecting and disseminating water pollution R&D information were not as useful as they might have been because they were not coordinated and most of the agencies were not actively promoting the use of available R&D data. We believe there is a need to coordinate the various systems for collecting and storing water pollution research information, identify the potential users of such information, and promote the dissemination of information in usable form. (See ch. 5.)

To be more responsive in meeting the R&D needs of its operating programs, EPA needs to improve the implementation of its planning system and document the rationale for decisions during its planning process, update water quality criteria more frequently, publish its processes-and-effects research results more promptly, and more fully support the R&D needs of enforcement and standard-setting activities through its AST program.

RECOMMENDATIONS TO THE ADMINISTRATOR, EPA

We recommend that the Administrator, EPA, prepare an R&D strategy to carry out EPA's R&D requirements under the Federal Water Pollution Control Act Amendments of 1972, estimate the funding required to meet these requirements, and present this information in its annual report to the Congress.

We also recommend that the Administrator:

--Place greater emphasis on developing and demonstrating new processes and techniques to minimize the cost of municipal water pollution control.

--Allocate a greater portion of its limited resources to the high-priority water pollution problem areas where the solution would have the greatest impact on improving the quality of the water.

--Fully document the basis for selecting and assigning priorities to R&D projects.

--Establish procedures for revising water quality criteria more frequently as new valid research results become available.

--Publish the results of EPA's processes-and-effects research more promptly and make such data available to EPA regional offices, State agencies, and other potential users.

- --Insure that the AST program is more responsive to the R&D needs of EPA's enforcement and standard-setting activities.

AGENCY ACTIONS

In its letter to us dated October 17, 1973, EPA stated that it basically agreed with our recommendations and has taken or plans to take the following actions.

- --Modified its OR&D planning process to insure greater responsiveness to the R&D needs of its operating and regulatory programs and started preparing R&D strategies to interface with these programs.
- --Will continue to examine into the need for more frequent revision of water quality criteria with the objective of finding optimal solution.
- --Established procedures to insure that processes-and-effects research results are published promptly.

MATTERS FOR CONSIDERATION BY THE CONGRESS

The attainment of the goals established by the 1972 amendments will require an ambitious R&D effort within a relatively short period of time. At the current funding levels for water pollution R&D, it is doubtful that these goals will be achieved within the time period established by the Congress. Therefore, the Congress should consider the current and planned funding levels for water pollution R&D in relation to research needed to determine if increased funding is warranted.

The 1972 amendments established a National Commission on Water Quality to study the technological aspects of achieving the effluent limitations and goals set forth for 1983 as well as all aspects of the total economic, social, and environmental effects of achieving or not achieving these limitations and goals. The Commission is required to report to the Congress by October 1975. If, on the basis of the results of the Commission's study, the Congress finds it necessary to reassess and revise legislative goals, it should determine the direction of Federal R&D programs--in terms of priorities and funding levels--to meet the revised goals.

CHAPTER 4

A NATIONAL PLAN NEEDED FOR IMPROVED COORDINATION OF FEDERAL WATER POLLUTION R&D

Federal water pollution R&D activities were conducted and/or supported by at least 25 bureaus, services, and offices in 12 departments and independent agencies. For the most part, these activities were not coordinated, and as a result, inadvertent duplication and overlapping of R&D activities occurred not only between the various departments and agencies but also between bureaus and services within the same departments. In addition, agencies disagreed at times on the feasibility of implementing R&D results. The following schedule shows the Federal agencies involved in water pollution R&D activities by research category. Appendix IV shows their funding for 5 fiscal years.

FEDERAL AGENCIES CONDUCTING AND/OR SUPPORTING

R&D RELATED TO WATER POLLUTION

Agency	Area of research						
	Processes and effects	Municipal technology	Industrial technology	Mining	Agriculture	Marine	Other
EPA	X	X	X	X	X	X	
Department of the Interior:							
Bureau of Land Management			X				
Bureau of Mines				X			
Bureau of Reclamation			X		X		
Bureau of Sport Fisheries and Wildlife	X		X		X		
Geological Survey	X		X	X	X		
Office of Saline Water	X		X	X	X		
Office of Water Resources Research	X	X	X	X	X		
Department of Agriculture:							
Agricultural Research Service (ARS)	X	X	X		X		
Cooperative State Research Service			X	X	X		
Economic Research Service			X		X		
Forest Service		X	X	X	X		
AEC	X		X				
Department of Transportation:							
Federal Highway Administration	X	X			X		X
U.S. Coast Guard						X	X
DOD:							
Air Force			X				
Army			X				
Corps of Engineers		X	X	X			
Navy	X		X		X	X	
National Science Foundation	X	X	X				
Department of Commerce:							
National Oceanic and Atmospheric Administration	X		X	X	X	X	
Department of Housing and Urban Development		X					
National Aeronautics and Space Administration			X				
Tennessee Valley Authority	X		X		X		
Department of Health, Education, and Welfare	X						

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COORDINATION OF FEDERAL WATER POLLUTION R&D PROGRAMS NOT EFFECTIVE

Although a multiple-agency approach to resolving water pollution problems may be advantageous and even desirable, the importance of an effective planning and coordinating mechanism increases as the costs of needed R&D exceed available resources.

No formal mechanism existed for coordinating the Federal water pollution R&D efforts among the many Federal agencies as well as non-Federal researchers.

OMB is responsible for insuring that Federal programs are properly coordinated and that appropriated funds are spent in the most economical manner with the least amount of inadvertent duplication and overlapping. OMB officials told us their involvement with program coordination and direction was limited to general guidance and direction; they were precluded from becoming too involved in program details because of staff limitations. Similarly, the Council on Environmental Quality, the President's advisory group on environmental matters, was also limited in coordinating Federal environmental programs.

In 1963, the Federal Council for Science and Technology established the Committee on Water Resources Research to coordinate water-related research activities of the Federal Government and to facilitate cooperation and communication between agencies. Throughout its 10 years of existence the Committee has been a focal point for water-related research matters, has provided a forum for an exchange of information between agencies, and has attempted to identify research needs and areas of priority. Because the Committee coordinates all water resources R&D, it cannot provide the attention required to adequately coordinate Federal water pollution R&D efforts. The chairman informed us that the Committee devotes only about 10 percent of its time to water pollution problems.

Other factors have also limited the Committee's effectiveness as coordinator for water pollution research. Originally established with a high-level membership, agency representation has been delegated to a level that is not authorized to make decisions regarding policy and program direction. One agency attendee at Committee meetings stated that it was not effective in coordinating research programs and that each agency undertook research that it thought necessary.

Throughout the Federal structure many interagency committees and agreements relate in some way to water pollution R&D matters. They vary extensively as to their scope, purposes, and effectiveness. None, however, provide for overall coordination of water pollution R&D activities. For example, under an interagency agreement, EPA and the Tennessee Valley Authority are jointly financing R&D concerning the effects of thermal pollution on aquatic life at Brown's Ferry, Alabama. This agreement, however, is not applicable to other agencies which are also conducting thermal pollution research, although the Authority told us that they were coordinating with other agencies.

Similarly, the International Great Lakes Study Group, formed in 1962, is an informal organization composed of representatives of agencies and institutions in Canada and the United States engaged in R&D related to the Great Lakes waters. Although the study group provides a good form for the exchange of research information, it has no formal mechanism to effectively coordinate research. Further, not all of the Federal agencies doing research on the Great Lakes are members.

Researchers told us they generally knew the other researchers and agencies performing work within similar areas but did not know the specific research being done. Coordination among individual researchers was through informal means (seminars, periodicals, etc.). Those responsible for planning and directing the programs had little knowledge of the nature and extent of other agencies' R&D efforts. Headquarters officials of several agencies told us they did not always know the R&D work being done in their own field laboratories. They said when they needed information on a specific project, they requested it from personnel responsible for the project at the field research facilities.

Officials within EPA and other Federal agencies generally agreed that water pollution R&D efforts lacked coordination, not only between, but within, the agencies. They also acknowledged the need for effective coordination to maximize the use of limited resources.

OVERLAPPING AND CONFLICTING R&D

Our review showed that inadequate coordination contributed to inadvertent duplication and overlapping of Federal agencies' R&D efforts. In addition, agencies disagreed at times on the feasibility of implementing R&D results. Improved coordination should result in more timely resolution of these disagreements.

Processes-and-effects research

EPA's laboratory in West Kingston, Rhode Island, and the Department of Commerce's laboratory in Milford, Connecticut, were doing or planned to do similar research on the effects of pollutants on marine organisms. For example, both laboratories were (1) investigating the effects and tolerances of heavy metal contaminants on marine resources and food chain organisms, (2) studying the ecological requirements for temperature, oxygen, and salinity, and (3) developing bioassay techniques and studying the physiological responses of fish. Both laboratories had performed or were planning to perform investigations on the effects of such metals as cadmium, chromium, copper, lead, mercury, nickel, and zinc on the same species of mollusks, crustaceans, finfishes, plants, and algae.

Although the two agencies held meetings at the headquarters level during 1971 and EPA officials concluded that no current or planned research was duplicative, the directors of each laboratory informed us, upon reviewing the other's research plans and programs, that significant overlap existed. Both stated their intentions to coordinate the laboratories' work.

The Department of Commerce in its letter to us dated October 26, 1973, stated that coordination efforts have been initiated.

In another case, we requested an EPA program official to review research summaries of 70 projects conducted by the Department of the Interior's Office of Water Resources Research, 9 projects conducted by the National Science Foundation, and 6 projects conducted by AEC on accelerated eutrophication and lake restoration. He told us he was aware of only a few of the projects and that 80 percent dealt with topics of concern to his program. Furthermore, he stated that it would have been of value to have his program personnel review and comment on project proposals, provided that the project results subsequently were furnished to him. (See pp. 55 to 58, enc. A.)

Municipal technology

EPA began a program in 1969 to develop phosphate-free laundry detergents in an attempt to reduce lake eutrophication. In addition, ARS has been investigating detergents for at least 30 years to develop new uses for agricultural products. EPA had spent about $800,000 on research to develop phosphate-free detergents through fiscal year 1973, while ARS spent about $2.2 million from fiscal years 1967 through 1973. Soap and Detergent Association officials estimated that their industry had spent approximately $170 million over the past 10 years on similar research.

Before awarding a contract in May 1970, EPA contacted ARS to determine if it was interested in competing for EPA funds to develop phosphate-free detergents. ARS was interested and forwarded a research proposal to EPA.

EPA officials informed us that they did not award the contract to ARS because they did not consider ARS' approach to phosphate-free detergents, i.e., the use of animal fats, to be the solution to the problem on a national scale. ARS then went ahead with the research described in the proposal and developed a phosphate-free detergent from animal fats. A large detergent manufacturer was test marketing the product as of June 1973.

EPA awarded its first contract for developing a phosphate-free detergent in June 1969. An EPA official stated that this contract was a limited effort designed to prod industry into accelerating its own research. Another contract was awarded to this contractor in October 1970. Reports were published for both contracts in December 1970 and February 1972, respectively. After evaluating a proposal to demonstrate these contract results, an EPA official stated in April 1972:

> "We [EPA] have decided not to continue this work. The formulation recommended by *** [the contractor] does not appear to be satisfactory for general household use as its washing ability varies greatly with the type of soil and fiber composition of the fabric."

In May 1970, EPA awarded a contract to develop phosphate-free detergents to a second contractor. An EPA officials stated that the interim results of that contract appear promising and may be demonstrated during fiscal year 1974 if funds are available.

EPA and ARS are both trying to develop phosphate-free detergents but apparently disagree as to whether such a detergent using animal fats can be developed and marketed nationally.

The Corps of Engineers and EPA have been doing R&D on the practicability of soil treatment systems. However, the R&D undertaken by these two agencies resulted in a conflict as to the practicability of soil systems in large urban areas. The Corps stated that soil systems were a viable alternative to conventional waste treatment, while EPA indicated that the health aspects and cost effectiveness of this method of treatment had not been sufficiently researched and demonstrated.

DOD officials informed us in October 1973 that both EPA and the Corps now agree that soil treatment is a viable, environmentally sound alternative which should be considered on a case-by-case basis to solve individual problems. (See pp. 23 to 30 and 49 and 50, enc. B.)

Applied science and technology

During our review of Federal agencies' AST research, we selected 263 projects in this area that the Departments of Agriculture and the Interior were conducting. We discussed these projects with EPA officials responsible for planning their agency's efforts in this area and were informed that they

--were directly aware of and had contributed to only 13 of the projects,

--were indirectly aware of and had not contributed to 72 of the projects, and

--were not aware of 178 of the projects.

Of the 263 projects, EPA officials believed that

--78 would be useful to them in solving identified problems,

--37 projects duplicated EPA projects or vice versa, and

--148 would not be useful to EPA because of project direction but many could have been if EPA had contributed to their direction. (See pp. 25 to 32, enc. C, for more details.)

LACK OF COORDINATION BETWEEN FEDERAL AND NON-FEDERAL RESEARCH EFFORTS

In addition to Federal agencies' water pollution R&D efforts, substantial R&D efforts were being undertaken by private industry, several of the States, universities, and others. Estimated R&D expenditures by non-Federal sources during fiscal year 1972 far exceeded Federal expenditures. However, no formal means existed for considering the R&D needs, priorities, and results of these non-Federal groups in planning the Federal water pollution R&D effort.

An EPA official told us EPA's planning system did not provide for assessing such groups' research results. Instead, EPA officials relied on program managers' and researchers' personal knowledge of other agencies' research. Officials of the AST Branch said their program lacked input from industry and other agencies, and they acknowledged a need for coordination to improve their program's effectiveness.

During discussions with representatives from industry and staff members of the National Industrial Pollution Control Council, we were informed that industry was reluctant to reveal to EPA the level of technology developed to control pollution because it might speed up its enforcement action, and industry therefore might suffer a financial loss. One industry representative stated that industry fears that, if it installs the best available treatment technology, subsequent upgrading of water quality standards or changes in legislation will require even greater levels of treatment without enough time to recover the cost of the treatment systems.

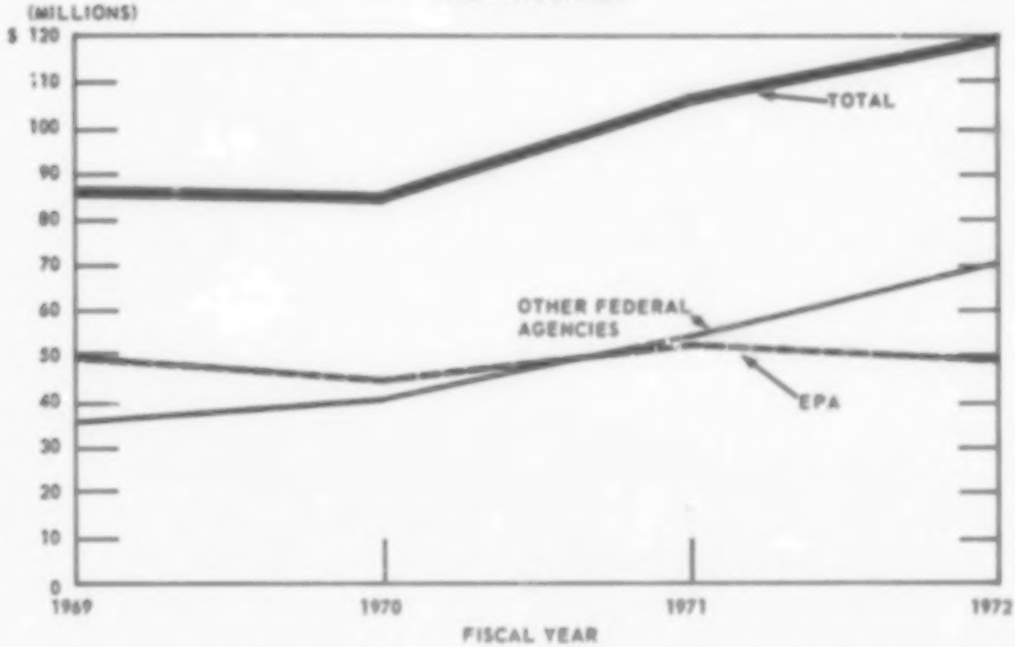
We sent questionnaires to each of the States and to 74 national industrial trade associations. Of 14 States with water pollution research programs, 6 believed their programs and those of the Federal Government were coordinated and complemented each other. Of the remaining eight States, four stated that their programs operated independently of the Federal Government's, three stated that their programs were partially coordinated, and one was unaware of the Federal effort.

NEED FOR A NATIONAL PLAN TO EFFECTIVELY COORDINATE WATER POLLUTION R&D

The Federal Water Pollution Control Act Amendments of 1972 directed EPA to establish National programs for preventing, reducing, and eliminating water pollution and, as part of such programs to cooperate with Federal, State, and other public or private agencies to

> "* * * promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of pollution ***." (Underscoring supplied.)

To meet the requirements of the 1972 amendments, we believe that EPA needs to establish, in cooperation with Federal and non-Federal agencies, a national water pollution R&D plan with specific goals, objectives, and priorities. The need for such a plan is emphasized by the fact that the cost of needed R&D far exceeds available funds. Further, because EPA's water pollution R&D funding has remained about the same during fiscal years 1969-72 and total Federal funding has increased and is expected to keep increasing, EPA should seek the cooperation and support of other Federal agencies as well as non-Federal organizations in implementing the plan. The following graph shows total Federal funding during fiscal years 1969-72.



FEDERAL FUNDING FOR WATER POLLUTION R&D PROGRAMS

The inadequate coordination of research efforts within the Federal Government and between Federal and non-Federal sources as previously described, tended to limit the effectiveness of the Federal R&D programs. We believe that the effectiveness of these programs will continue to be limited unless all Federal R&D activities are coordinated and directed toward common goals and objectives.

There is much expertise available outside EPA that can contribute to solving water pollution problems if properly directed. For example, Department of Agriculture officials told us pollution from animal feedlots and sedimentation are agricultural problems and that they have expertise in these areas. Other Federal agencies and non-Federal groups also have expertise in their specific areas. In our opinion, all available expertise and resources should be used in developing and implementing a national water pollution research plan.

As we envision it, the national plan would provide for (1) an inventory of water pollution R&D needs, classified as to relative importance, (2) identification of R&D efforts being undertaken by Federal and non-Federal organizations with respect to the areas of need, and (3) periodic reporting to EPA by research organizations as to accomplishments, difficulties being encountered, funds expended, and other pertinent aspects of the R&D programs; and would serve as a basis for EPA to help steer R&D efforts of interested parties into channels of greatest need, minimize unnecessary duplication of effort, and promote economies. Also, effective implementation of such a plan would enable EPA to provide the Congress and the Executive Branch with periodic overviews of the progress achieved, problems encountered, and Federal funds expended to attain the goals of the Federal Water Pollution Control Act as amended.

It has been said that the users of research are best qualified to determine what research needs to be done, scientific and technical personnel are best qualified to determine what research can be done, and research planners and managers are best qualified to determine what research is worth doing. We believe that these three groups in Federal and non-Federal agencies should work together under EPA's leadership to identify and define those water pollution problems needing research, to determine R&D goals and objectives, and to establish priorities.

We have discussed such an approach with scientific and technical personnel, both within and outside the Federal Government; research program planners and managers; and environmental policymakers. Most of those we talked with stated that such an approach was not only feasible but also desirable.

In this regard, a recent reorganization of EPA's R&D program created the Office of Principal Science Advisor, consisting of an in-house staff of senior science advisors and a science advisory board to the Administrator. The senior science advisors provide special studies and consultation on technical matters to the Assistant Administrator, OR&D, as well as to others in OR&D. The board, consisting of specialized advisory committees whose members are outside EPA, provides expert, independent advice on issues relating to scientific and technical problems, agency strategies, technical programs, and program priorities.

It also advises on scientific relationships with Federal and non-Federal groups, assesses specific R&D results, identifies problems, and makes sure the agency's scientific programs are current, and inadvertent duplication of effort is avoided.

The Office of Principal Science Advisor could be the mechanism within EPA responsible for preparing a national plan to coordinate water pollution R&D. It then would be up to EPA to seek the cooperation of other Federal and non-Federal agencies to successfully implement the plan.

CONCLUSIONS

Each year millions of dollars are spent to solve the Nation's water pollution problems. To a large extent such efforts have been diverse, fragmented, and uncoordinated. We believe that a national water pollution R&D plan aimed at improved coordination of Federal R&D efforts is needed if water pollution control goals are to be achieved.

In our opinion, EPA should develop such a plan. The plan should encourage an integrated, systematic, comprehensive approach to water pollution research through the use of the water pollution R&D expertise of all Federal and non-Federal agencies and of the States, industry, and universities, and should be revised and updated on a continuous basis. After the plan has been developed, EPA should actively seek the cooperation and support of other Federal agencies and non-Federal researchers in implementing it.

OMB is responsible for insuring that Federal agency programs are coordinated and that funds are spent in the most economical manner with the least amount of duplication and overlapping of effort. We believe that OMB's support would be essential if a national plan for improving coordination of water pollution R&D is to be successfully developed and effectively implemented. OMB should therefore assist in obtaining the full cooperation and support of all Federal agencies engaged in water pollution R&D in the development and implementation of the plan.

RECOMMENDATION OF THE ADMINISTRATOR, EPA

We recommend that the Administrator, EPA

- develop, in cooperation with Federal and non-Federal organizations, a national plan for improved coordination of Federal water pollution R&D, and

- seek the cooperation and support of these organizations in implementing the plan.

RECOMMENDATION TO THE DIRECTOR, OMB

In view of OMB's role in promoting efficiency and economy in Government operations, we recommend that the Director, OMB, actively participate with EPA in obtaining the full cooperation of all Federal agencies engaged in water pollution R&D in the development and implementation of a national water pollution R&D plan.

AGENCY COMMENTS

EPA, in its letter to us dated October 17, 1973, stated that it:

> "* * * does not have the resources for the development and/or the authority for a truly effective coordination of a national water pollu-R&D plan or for adequate coordination of Federal research on the Great Lakes. In this regard, EPA is reluctant to undertake such endeavors without legislatively defined authority."

We believe that, with the support of OMB, EPA could effectively develop and implement a national water pollution R&D plan.

MATTERS FOR CONSIDERATION BY THE CONGRESS

EPA relies on industry's voluntary release of information on its R&D efforts and results in deciding which R&D water pollution projects to pursue. During our review, we became aware of some reluctance by industry to provide the information. A free and full exchange of such information--under proper safeguards to avoid public disclosure of proprietary information and under assurances that such disclosure will not adversely affect industry's pollution control program--should be of mutual benefit and should help avoid unnecessary duplication of R&D. The Congress may wish to explose with EPA and industry whether the current procedures for exchanging such information can be strengthened.

CHAPTER 5

DISSEMINATING RESEARCH INFORMATION

Both the Congress and the President have expressed concern over the limited use of the results of R&D programs sponsored or supported by Federal funds. To maximize the use of Federal R&D accomplishments, results must not only be available to potential users but also must be in a form that encourages use of the information. A number of Federal agencies collect and disseminate water pollution R&D information. These agencies' data systems, however, were not coordinated and were not as useful as they might have been to those interested in the results of water pollution R&D efforts.

We believe there is a need, within the Federal structure, to coordinate the various systems for collection and storage of water pollution R&D information, help identify the potential users of such information, and promote its dissemination in usable form. We believe this could be accomplished by OMB designating a Federal agency to act as a focal point for this purpose.

NEED FOR BETTER COORDINATION OF WATER POLLUTION RESEARCH INFORMATION

Several studies have identified the need for better coordination of Federal research information. A report by the President's Science Advisory Committee issued in January 1963 recognized that effective science and technology is a national necessity, that adequate communication is a prerequisite for effective science and technology, and that the health of the technical communication system must be a serious concern of the Government. During June 1970 the Subcommittee on Fisheries and Wildlife Conservation and the Environment, House Committee on Merchant Marine and Fisheries, held hearings on bill to amend the National Environmental Policy Act of 1969 to provide for a national environmental data bank which would serve as the central national facility for selecting, storing, analyzing, retrieving, and disseminating data specifically relating to the environment. These bills would have established a network linking agency systems which contain environmental research.

In our report to OMB entitled "Coordination of Computerized Information Systems Reporting on Active Research Efforts" (B-115398, Mar. 29, 1973), we stated that:

> "One matter of concern in improving the Government's ability to manage a large and diverse science program has been the need to improve the flow of information to the top levels of Government and to coordinate large and often overlapping research activities among agencies."

OMB is responsible for coordinating agency programs and in so doing it develops mechanisms to implement Government activities, including scientific and technological programs.

Systems now used for disseminating information

Several major Federal systems now disseminate scientific and technical information relating to water pollution. The Office of Water Resources Research (OWRR) of the Department of the Interior operates the Water Resources Scientific Information Center (WRSIC), which is the major Federal center for water resources information, including water pollution research information. Other important Federal information systems are the Science Information Exchange (SIE) of the Smithsonian Institution, which has a computerized data bank on all ongoing Federal research, and the National Technical Information Service (NTIS) of the Department of Commerce, which sells copies of reports on completed research Federal agencies made available to it.

The Government Printing Office (GPO) prints and sells agency reports in the water pollution field, and the National Referral Center of the Library of Congress provides a referral service in the water resources area. These systems are described more fully below.

WRSIC

In 1966, the Federal Council for Science and Technology designated WRSIC as the national center for scientific and technical information on water resources. WRSIC seeks to collect and disseminate scientific and technical information to the national water resources community primarily by publishing an annual catalog of active research projects and by publishing selected abstracts semimonthly. It is also experimenting with computer research services on selected topics and occasionally publishes indexes, topical bibliographies, and state-of-the-art reviews.

WRSIC covers water resources research, not just water pollution research. It uses existing research resources and the expertise of Federal agencies, universities, and other organizations, including the major information and documentation services, as sources of processed information. It also gets information from universities with active research programs in water resources, State water resources research institutes, OWRR contractors and grantees reporting on supported research projects, and Federal agencies with water-related research programs through exchange agreements with OWRR. Supplementary documentation is secured from established, discipline-oriented abstracting and indexing services.

In addition, selected organizations with active water resources research programs are considered "centers of competence," responsible for selecting, abstracting, and indexing information from literature in specific subject areas. EPA also uses some universities to aid in searching the literature and preparing abstracts.

SIE provides WRSIC with information on active Federal research projects.

SIE

SIE is a clearinghouse for information on active research in the physical, biological, and social sciences. The information is compiled to facilitate more effective planning and coordination of R&D programs sponsored or supported by Federal funds.

The Water Resources Research Act of 1964 required the President to establish a catalog center for water resources research and also required each Federal agency doing water resources research to cooperate by giving the center information on work underway or scheduled. Presidential memorandum number 1766, dated October 24, 1964, designated SIE as the cataloging center for active and projected scientific research in all fields of water resources.

SIE gathers current information on Federal, State, and local agencies' research projects and on nonprofit, educational and commercial research organizations. The information includes the organizations doing research, the supporting organizations, the title of the research project, a brief description of the research objectives, the names of the principal investigator and coinvestigators, the period of performance, and funding. The information is then indexed and is entered into a computer.

Information in the form of statistical summaries, tabulations, and computer printouts is available to any scientist, research administrator, investigator, or manager for a fee which is intended to recover service costs. In addition, SIE does computer searches of current and historical projects and collects data for catalogs.

NTIS

NTIS, previously known as the Clearinghouse for Federal Scientific and Technical Information, was established by the Secretary of Commerce to simplify and improve access to Department of Commerce publications and to other data files and scientific and technical reports that other agencies make available to it.

As of August 1972, the information base on which NTIS depends consisted of over 680,000 reports and analyses, all of which are for sale. NTIS produces several publications and abstracts on a weekly and semimonthly basis, as well as a Government-reports index which provides subject, authors, Government contract, and order number.

In addition to these publications, NTIS provides online computer searches of its data bank, sells microfilm copies of abstracts by selected categories, and sells magnetic tapes containing data on highly defined topics. NTIS also coordinates the marketing of the products and services of more than 100 federally sponsored information analysis centers.

GPO

GPO sells agency publications to the general public, but it does not consider itself an information center; accordingly, its bibliographic reference services are limited.

National Referral Center

The National Referral Center of the Library of Congress provides advice on where to obtain information on specific topics in science and technology but does not provide technical details to answer inquiries, nor does it furnish bibliographic assistance. The Center directs inquiries to the appropriate people and organizations by providing requestors with names, addresses, telephone numbers, and statements regarding any special conditions of service imposed by the information sources.

Under the general title "A Directory of Information Resources in the United States," the Center has compiled a number of guides which are revised periodically. A guide on water was produced in 1966 but is not currently scheduled for revision.

Systems not coordinated or complete

Currently there is no one central source for information on Federal water pollution research. The diagram on page 87 shows that users must seek information from many sources, including WRSIC, NTIS, SIE, and agency data banks which, for the most part, operate independently.

In April 1973, SIE and NTIS initiated, under a joint agreement, a search service through which a user can obtain information from both data bases through a single request from either organization and at a lesser cost than going to each individually. Although this agreement improves coordination between these organizations and access to their data bases by users, other problems still exist.

A problem hindering coordination is the lack of a standardized language in the water pollution field. For example, EPA classified its research by "program element;" however, none of the other agencies included in our review used this system. We found it difficult, and in some cases impossible, to categorize other agencies' research by this system.

At the technical language level, WRSIC has published "The Water Resources Thesaurus" for indexing and retrieving the literature of water resources research. The thesaurus was developed under contract with SIE. While WRSIC claims it encourages its users to use the language in the thesaurus, we found no indications that other agencies used the thesaurus or considered it a standard language.

Another problem noted was that none of the information systems were complete or comprehensive in coverage. For instance, SIE collects data on active research only, while NTIS is concerned only with reports of completed research. Although agencies are required by Presidential memo to submit notices of water resources research to SIE, our limited sample of SIE's data indicated that the information was not complete. In addition, agency officials told us they made only limited use of SIE because the data was incomplete, not up to date, and unreliable.

Agencies are not required by law to submit reports to NTIS for dissemination, although most do so voluntarily. Consequently, NTIS did not have data on all completed research in the water pollution field.

WRSIC depends on SIE for its information on active research and relies on its centers of competence to abstract reports on completed research. Some crosscheck is provided when WRSIC reviews NTIS abstracts. Thus, WRSIC, which provides only limited coverage, relies on other incomplete sources for its data.

Although some Federal agencies that conduct or support research have developed or were developing automated systems for acquiring, storing, and retrieving information, most of the systems in our review were limited, which adversely affected their usefulness.

Our review showed that many users tended to rely on scientific and professional journals for acquiring and disseminating knowledge rather than on systems, such as WRSIC, SIE, and NTIS.

Below are examples of other inadequacies in present dissemination systems.

--Reports are not available to interested potential users.

--Researchers are not aware of other agencies' projects in similar areas of work.

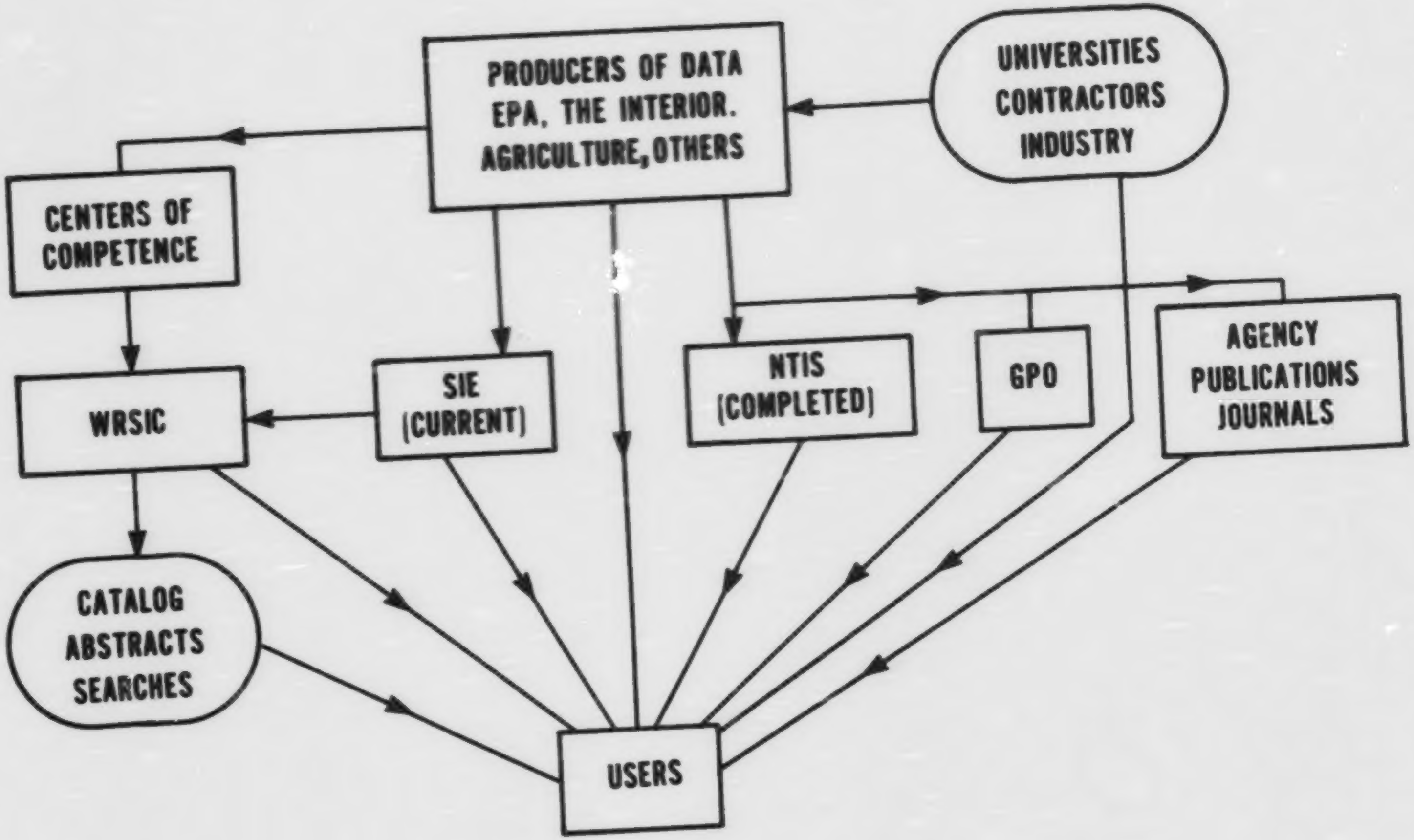
--Research reports are not written in a manner that is readily understood or of interest to potential users. Often they were written for other researchers rather than for operational users.

A MODEL INFORMATION CENTER FOR WATER POLLUTION RESEARCH

Any of the systems for disseminating water pollution research information could, with appropriate modifications to their authority and organizational structure, serve as an information center to identify all available water pollution R&D information, collect and analyze the information, and provide it to potential users in usable form. To illustrate how such a center could improve the coordination and dissemination of water pollution research information, we selected WRSIC to serve as a model.

The following two diagrams show the current water pollution data system and the possible arrangement if WRSIC were designated as the focal point for dissemination. Under the arrangement shown on page 88, WRSIC (1) would have access to water pollution research information from SIE, NTIS, Federal agencies, industry, and other non-Federal sources, (2) identify the users of research information, (3) have the information analyzed by information analysis centers or universities, and (4) disseminate the information and its sources to users in the form of thesauruses, catalogs, abstracts, special technical analyses, and state-of-the-art monographs.

CURRENT SYSTEM FOR DISSEMINATING WATER POLLUTION DATA



PRODUCERS OF DATA
EPA, THE INTERIOR.
AGRICULTURE, OTHERS

UNIVERSITIES
CONTRACTORS
INDUSTRY

CENTERS OF
COMPETENCE

WRSIC

SIE
(CURRENT)

NTIS
(COMPLETED)

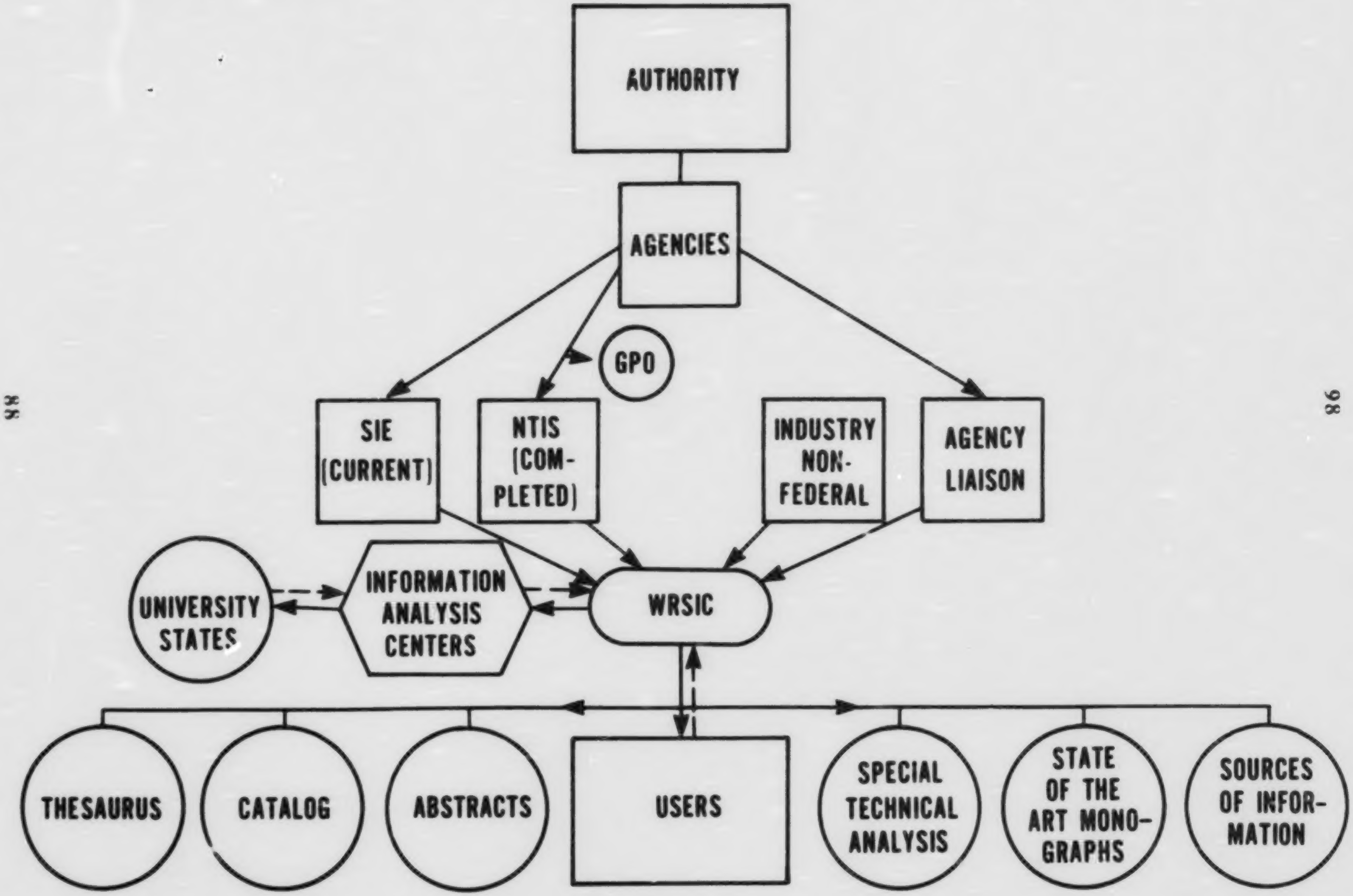
GPO

AGENCY
PUBLICATIONS
JOURNALS

CATALOG
ABSTRACTS
SEARCHES

USERS

MODIFIED SYSTEM FOR DISSEMINATING WATER POLLUTION DATA



AUTHORITY

AGENCIES

GPO

SIE (CURRENT)

NTIS (COMPLETED)

INDUSTRY NON-FEDERAL

AGENCY LIAISON

UNIVERSITY STATES

INFORMATION ANALYSIS CENTERS

WRSIC

THESAURUS

CATALOG

ABSTRACTS

USERS

SPECIAL TECHNICAL ANALYSIS

STATE OF THE ART MONOGRAPHS

SOURCES OF INFORMATION

WRSIC could provide EPA and other Federal agencies with pertinent information to help identify additional research required, establish priorities, and identify possible solutions to significant problems; it could also serve as a support service and/or switching terminal for seekers of specialized information, including non-Federal users. To carry out these functions, WRSIC would have to be modified to include the following.

Use an active approach to disseminate information

The dissemination of research information can be active or passive. Passive methods usually involve collecting, screening, indexing, storing, and disseminating scientific and technical information. Active methods usually involve certain elements of passive methods supplemented by personal liaison between research personnel who develop technology and potential users of the technology, aided by third party (WRSIC) transfer agents. This liaison helps define users' problems and identify existing relevant technology.

In our report to the Congress entitled "Means for Increasing the Use of Defense Technology for Urgent Public Problems" (B-175132, Dec. 29, 1972), we stated:

> "* * * The limitations of passive dissemination efforts have been widely recognized throughout the Government. For example, a Department of Commerce report dated November 17, 1969, prepared for various Senate committees, cited the ineffectiveness of technical reports as transfer mechanisms. The report stated:
>
> > "That DOD, AEC, and NASA have developed many new devices and (problem) solutions is beyond question.* * *the publication and dissemination of technical reports relative to these developments are essential but it does not go far enough. There is a very low probability that a report will arrive at the desk of someone who can match that particular problem.'"

Our report also stated:

> "Disseminating scientific and technical information alone, particularly in the form of technical reports, even with the aid of a computerized search service, is not generally adequate for transferring technology. Identifying relevant technology through publications is only one facet of the transfer process."

Most of the Federal information systems we reviewed were primarily passive and therefore did not promote acceptance and use of information in the problem-solving or decisionmaking process.

In focusing attention on the water pollution problem, WRSIC would assume a more active role by providing comprehensive coverage of water pollution research information and applying research to identified problems. It would also be in a better position to help bridge the gap between the researchers who deal with new knowledge and the engineers and technicians who implement it and solve practical problems.

Establish information analysis centers

The Committee on Scientific and Technical Information of the Federal Council for Science and Technology has defined an information analysis center as follows:

> "An information analysis center is a formally structured organizational unit specifically (but not necessarily exclusively) established for the purpose of acquiring, selecting, storing, retrieving, evaluating, analyzing, and synthesizing a body of information and/or data in a clearly defined specialized field or pertaining to a specific mission with the intent of compiling, digesting, repackaging, or otherwise organizing and presenting pertinent information and/or data in a form most authoritative, timely, and useful to a society of peers and management."

In view of this definition and in an effort to place greater emphasis on transferring technology and applying research information, WRSIC would need to evaluate the role of its existing centers of competence,[1] coordinate with EPA and other Federal agencies having information analysis centers, and provide for establishing more centers where appropriate.

WRSIC could serve as a switching point for coordinating these centers' services with users' needs. Increased use of information analysis centers could make the designated focal point a stronger, more active, and more useful information center for disseminating research information.

Coordinate with data-gathering agencies

WRSIC would need to explore ways of coordinating the data of other agencies, such as the Geological Survey (e.g., hydrologic data, water analysis, etc.), with its own information-gathering and analysis activity so that they might supplement and complement each other.

CONCLUSIONS

Our review of the dissemination of water pollution research information revealed a lack of

--a central organization in the Federal Government for identifying and coordinating available information and information sources,

--technical analyses of research data to apply research results to water pollution problems,

--effort, by those groups responsible for gathering information, to identify the users of research data and their needs, and

---

[1] The centers of competence currently supported by WRSIC and EPA appear to fall short of the information analysis center concept described above because their scope of activity and services provided are limited. Agency officials indicated that funding restraints have prevented the centers of competence from fully developing along the lines of the above definition.

- --an accepted common language at the program and technical levels for categorizing, indexing, and otherwise managing and transferring technical information.

We believe that designating an existing information center as a focal point for coordinating and disseminating water pollution research results, and establishing criteria and procedures for transmitting these results to established collection and storage centers, together with increased cooperation from Federal agencies and OMB, would alleviate these problems and foster better use of Federal research information.

RECOMMENDATIONS TO THE DIRECTOR, OMB

We recommend that the Director, OMB

- --designate a Federal agency as a focal point to coordinate and promote the dissemination of water pollution research results, and

- --establish criteria and procedures for transmitting all water pollution R&D technical reports and program information to established centers for collecting and storing this information.

AGENCY COMMENTS

In commenting on the matters discussed in this report, EPA stated, in a letter dated October 17, 1973, that:

> "EPA fully supports this recommendation. However, it is abundantly clear that such an information focal point should not be limited to water pollution but should extend across the entire area of environmental protection. Because of EPA's predominant role in the environmental area, we feel that such a focal point should be established within EPA. This is a logical and sound conclusion since this Agency has the responsibility under its basic charter to be the focal point for environmental information. On June 1, 1973, EPA initiated a contract for the purpose of developing a plan for the creation of a scientific and technical information network utilizing EPA's information resources

> as well as those of other Agencies that relate to the EPA mission." (See pp. 95 to 99.)

NTIS in its letter to us dated September 28, 1973, stated that it agreed with the basic finding that a strong central focal point within the Federal Government for coordinating water pollution research information sources would be desirable, but that WRSIC, the focal point used as an example, should not perform the functions of collecting, storing, and disseminating water pollution research information. NTIS said that this would lead to unnecessary duplication of the functions of NTIS and SIE. (See pp. 114 and 115.)

We agree with NTIS and believe that the central Federal information center should coordinate the collection and dissemination of water pollution research results contained in existing data banks.

SIE in its letter to us dated October 9, 1973, stated that:

> "We see no problem in the suggestion proposed by GAO for designating WRSIC as the focal point for dissemination and utilization of research information if, as proposed, WRSIC would continue to make use of SSIE [SIE] rather than try to duplicate or maintain the file on current research now held by SSIE since this data is readily available to WRSIC. In fact, the plan as envisioned should increase use of SSIE data by WRSIC, a highly desirable objective especially in preparing state of the art reports." (See pp. 126 to 128.)

WRSIC was used as an example in the report on how a central information center could improve the coordination and dissemination of water pollution R&D information. Any of the systems for disseminating water pollution research information could, with appropriate modifications, serve as a central Federal information center. We believe that OMB should designate such a center.

AGENCIES AND ORGANIZATIONS THAT REVIEWED THE REPORT OR REPORT SECTIONS

Agency or organization	Reviewed					Comments on page
	Vol. I	Vol. II	Enc. A	Enc. B	Enc. C	
EPA	x	x	x	x	x	95
Department of the Interior	x	x	x		x	(a)
Department of Agriculture	x			x	x	100
AEC	x	x			x	104
Department of Transportation	x	x			x	105
DOD	x	x		x	x	106
National Science Foundation	x	x	x		x	110
Department of Commerce	x	x	x		x	111
National Aeronautics and Space Administration	x	x				117
Tennessee Valley Authority	x				x	118
Department of Health, Education, and Welfare	x	x	x	x	x	119
Department of Housing and Urban Development	x					(a)
Office of Management and Budget	x	x	x	x	x	(a)
Department of State		x				120
Council on Environmental Quality	x	x	x	x	x	122
National Academy of Sciences	x	x	x	x	x	123
Smithsonian Science Information Exchange	x					126
Great Lakes Basin Commission		x				129
International Joint Commission		x				132

[a] No formal comments received.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 17 1973

OFFICE OF
PLANNING AND MANAGEMENT

Mr. Edward A. Densmore, Jr.
Assistant Director, Resources
and Economic Development Division
General Accounting Office
Washington, D. C. 20548

Dear Mr. Densmore:

The draft of your Report to the Congress of the United States, entitled "Study of Federal Water Pollution Research and Demonstration Programs," has been reviewed and discussed by members of the Environmental Protection Agency and your staff at various stages during its development.

In general, we find the draft submitted for final comments to be accurate to the extent possible in such a study, and we are in basic agreement with the recommendations contained therein. However, we do wish to submit specific comments on areas where it is felt that the Agency's point of view has not been fully reflected in the study.

Of the several recommendations made in this Report, we feel five are directly related to the OR&D Needs System. Therefore, we have taken the liberty of addressing these recommendations collectively.

The Report recommends that the Administrator of EPA:

"...should prepare an R&D strategy to carry out EPA's R&D requirements under the Federal Water Pollution Control Act Amendments of 1972,

* * * *

--Allocate a greater portion of its limited resources to the higher priority water pollution problem areas where the solution would have the greatest impact on improving the quality of the water.

--Fully document the basis for selecting and assigning priorities to R&D projects.

* * * *

--Insure that the AST program is more responsive to the R&D needs of EPA's enforcement and standard setting activities.

* * * *

--Initiate and carry out a comprehensive Great Lakes processes-and-effects research program aimed at determining the sources, quality, dispersion, fate, and effects of pollutants,..."

As FY-74 program plans were being developed, it became obvious that the Needs System of the Office of Research and Development, as then structured, should be modified and extended to increase its effectiveness in optimizing R&D responsiveness. Consequently, during the summer of 1973, a detailed review was made by OR&D of the Needs System to determine the best means of enhancing its effectiveness to insure that the research which is planned and accomplished coincides with the requirements of Agency operating programs and is in support of our regulatory programs. Subsequently, OR&D's planning process was modified to structure four points of interface with the rest of the Agency during the annual planning cycle.

These points of interface begin with a target-setting council in which the Assistant Administrator for Research and Development receives counsel from the other Assistant Administrators, i.e., the Agency's National Program Managers, regarding initial resource targets for each of the eleven research program areas.

The second interface consists of a series of meetings between the OR&D technical staff and the technical staffs of the other program offices following their submission of Needs Statements. The objective is to develop common understandings of the Needs Statements and to assure that each Need expresses an identifiable aspect of a national program strategy, that it is not satisfied by ongoing or completed programs, and that the expected products of research and the scope of effort required are clearly understood.

The third interface consists of caucuses with the program offices after OR&D's detailed plans have been prepared. This interface is largely a review at the technical staff level of the complete set of plans for the coming fiscal year along with the resource targets and tentative priorities for each research program area.

The final interface is among the Assistant Administrators prior to the submission to the Agency's Program Planning and Review Group of OR&D's proposed program plan. This interface is meant to resolve any remaining issues concerning the responsiveness of the OR&D plan.

OR&D now plans to superimpose the discipline of preparing (in conjunction with the program offices) and pursuing strategies for research relevant to program requirements. These research strategies are to be interfaced with the regulatory program strategies, and will be a vital aspect of each of the interfacing procedures discussed above.

The first interaction in the FY-75 OR&D planning cycle occurred in September. Preliminary resource targets for the various "media," including water, and for each OR&D program area were established. At the present time, these targets are being reviewed by the program offices, and they, in turn, will submit a formalized and documented input to the OR&D Needs System.

We feel confident that the planning process as modified above will assure more complete responsiveness to the R&D needs of the Agency.

The Report further states that the Administrator should:

> "--Establish procedures for revising water quality criteria on a more frequent basis as new valid research results become available."

We agree that more frequent revision of the water quality criteria is desirable. However, past experience has proven that regularly scheduled updating of a formal document is impractical. This is primarily because the criteria is based on research results which must be critiqued by specialists before revisions can be made, and this requires time. The Agency will, however, continue to examine this problem with the objective of finding an optimal solution which will provide more frequent revision and dissemination of new or revised criteria.

> "--Publish the results of EPA's processes-and-effects research in a timely manner and make such data available to EPA regional offices, State agencies, and other potential users."

The problems causing delays in the publication of research results have previously come to the attention of the management of EPA, and corrective measures are now underway. The problems basically evolved from funding procedures. Funds for publication of results were not reserved in advance and, when reprogramming was needed, the procedures required more time than should be necessary. To correct this situation, advance recognition is to be made of the cost of publication of final reports, and funding/reprogramming procedures have been made almost automatic. In addition, the status of the publication of reports will be monitored as part of OR&D's over-all management information system to assure timely publication.

The Report also addresses the subject of coordination of Federal water pollution R&D programs, and recommends that the Administrator:

"--develop, in cooperation with Federal and non-Federal organizations, a national water pollution R&D plan, and

--seek the cooperation and support of these organizations in implementing the plan.

* * * *

--exercise leadership, in cooperation with IJC, in improving the coordination of Federal water pollution research on the Great Lakes."

While EPA is doing its best to provide leadership to a coordinated Great Lakes water pollution research effort (e.g., Dr. Greenfield, EPA's Assistant Administrator for R&D, serves as Co-Chairman of the Research Advisory Board of the Great Lakes of the International Joint Commission), it must be pointed out that EPA does not have the resources for the development and/or the authority for a truly effective coordination of a national water pollution R&D plan or for adequate coordination of Federal research on the Great Lakes. In this regard, EPA is reluctant to undertake such endeavors without legislatively defined authority.

The final recommendation made in this Report is addressed to the Director, OMB, and states:

"The Director, OMB should also:

--Designate a Federal agency as a focal point for coordinating and disseminating water pollution research results, and

--establish criteria and procedures for transmitting all water pollution R&D technical reports and program information to established centers for collecting and storing this information."

EPA fully supports this recommendation. However, it is abundantly clear that such an information focal point should not be limited to water pollution but should extend across the entire area of environmental protection. Because of EPA's predominant role in the environmental area, we feel that such a focal point should be established within EPA. This is a logical and sound conclusion since this Agency has the responsibility under its basic charter to be the focal point for environmental information.

On June 1, 1973, EPA initiated a contract for the purpose of developing a plan for the creation of a scientific and technical information network utilizing EPA's information resources as well as those of other Agencies that relate to the EPA mission.

In summary, your recommendations are considered to be constructive criticisms which will aid the Environmental Protection Agency in continuing to direct our R&D efforts toward achieving the goals of the Federal Water Pollution Control Act Amendments of 1972.

Sincerely,

Alvin L. Alm
Assistant Administrator
for Planning and Management

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

OCT 17 1973

Mr. Richard J. Woods
Assistant Director
Resources and Economic
Development Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Woods:

Members of my staff have reviewed your draft report entitled "Study of Federal Water Pollution Research and Demonstration Programs." They find nothing in the report that we would take issue with. The stress in the report for more effective coordination of research efforts has our full support. A number of meetings that will be concerned with coordination mechanisms have been scheduled between EPA and ARS scientists and administrators.

Sincerely,

Ralph J. McCracken

Ralph J. McCracken
Acting Administrator

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Washington, D. C. 20250

1420

OCT 23 1973

Mr. Richard J. Woods
Assistant Director
Resources and Economic Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Woods:

We have reviewed the General Accounting Office report on Federal Water Pollution Research and Development Programs and offer the following comments:

1. Page 4a. Development of a national water pollution R&D plan should consider the responsibilities, missions, and priorities of a number of agencies. National priorities for Applied Science Technology programs will no doubt differ among agencies since their missions differ. In the case of the Forest Service, these mission-type R&D programs are necessary to satisfy our management objectives. We believe that coordination is needed in many specific research areas and that agencies with competency in particular aspects of water quality research should maintain that competency.

2. Page 5. The problem of a central system for research information is already being partially addressed by the Water Resources Scientific Information Center which presently plays an important role as a central point for abstracting water resources reports. Forest Service watershed research publications are routinely abstracted and sent to the Center. The role of this center as a focal point for water pollution R&D reports might be strengthened rather than establish a new organization.

3. Enclosure B, page 31+. The draft does not recognize ongoing efforts at coordination of research on sewage effluent and sludge recycling on land. In August 1972, EPA, several universities, and USDA organized a "Subcommittee on Recycling of Municipal Sludge and Effluents on Lands." The subcommittee has had a number of meetings and has sponsored a workshop to develop plans for coordinated activities involving industry, the States, and Corps of Engineers, as well as EPA, universities, and USDA. The Forest Service is a member of this formal committee.

4. Enclosure C, page 44. The proposed Forest Service R&D program for Forestry, Advanced Logging, and Conservation (FALCON) is mentioned in the report as being parallel to the EPA work plans for solving logging and erosion problems. FALCON actually addresses advanced logging and timber production problems well beyond the water-quality-related EPA effort. Some Forest Service research on the effects of logging on specific water quality values has been underway for several decades. Several recent reports by EPA have referenced this research.

We would appreciate receiving copies of the final report.

Sincerely,

J. W. Deinema
for JOHN R. McGUIRE
Chief

GAO note: Page references refer to a previous draft report and are not applicable to this report.

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF THE INSPECTOR GENERAL
WASHINGTON, D.C. 20250

OCT 4 1973

Mr. Richard J. Woods
Assistant Director In Charge
Resources & Economic Development Division
U.S. General Accounting Office
Room 6639 South Agriculture Building

Dear Mr. Woods:

OIG has reviewed your draft report, dated September 14, 1973, entitled "Study of Federal Water Pollution Research and Demonstration Programs," and has no comments.

Comments on this report by the Forest Service and Agricultural Research Service will be forthcoming.

Sincerely,

RODNEY L. ELAM
Acting Deputy Assistant Inspector
General
Analysis and Evaluation

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

OCT 24 1973

Mr. Hugh J. Wessinger
Assistant Director
Resources and Economic
Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Wessinger:

We have reviewed Volumes I and II and Enclosures A and C of the draft of the proposed report to the Congress on the results of GAO's study of Federal water pollution research and demonstration programs transmitted with your letter dated September 18, 1973.

In addition to our detailed comments which are enclosed, there is one general observation we would like to make. This concerns the GAO recommendation that the administrator of EPA should assume the responsibilities of developing and implementing a national water pollution research and demonstration plan.

It would seem more appropriate to us for the Council on Environmental Quality to undertake supervision of a national plan. It is neither a regulatory agency nor a user agency; thus, there is greater assurance that the Council would oversee compliance with the requirements of the NEPA. Further, in this role the Council could assure that all other environmental factors, such as land use, air pollution control, and solid waste disposal, are appropriately considered in preparation of a national water pollution research and demonstration plan.

We appreciate the opportunity of offering comments on the proposed report and believe the final report should be a valuable document in focusing attention on the more immediate problems of water quality needing to be attacked.

Sincerely,

John A. Erlewine
General Manager

Enclosure:
AEC Detail Comments

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

ASSISTANT SECRETARY
FOR ADMINISTRATION

October 12, 1973

Mr. Richard W. Kelley
Associate Director, RED Division
U.S. General Accounting Office
400 7th Street, S W.
Washington, D.C. 20590

Dear Mr. Kelley:

This is in response to your letter of September 17, 1973, requesting comments on the General Accounting Office's draft report entitled, "Study of Federal Water Pollution Research and Demonstration Programs."

GAO recommends establishment of a Federal focal point for collecting, storing, and disseminating water pollution research information. To this end, GAO directs specific recommendations to the Administrator of the Environmental Protection Agency and the Director of the Office of Management and Budget. In general, the Department supports the findings that management and coordination of these programs need to be improved; there is a need for a national water pollution R&D plan; and the water pollution control effort would benefit from a central system to disseminate research information. The Department conducts an effective program of marine pollution research and development, and demonstration through its Coast Guard organization. This program is producing substantial results to assist in carrying out the Department's statutory responsibilities in the areas of water pollution control and related law enforcement. The Department actively coordinates with EPA and other agencies concerning environmental matters and is prepared to continue to cooperate fully in these programs.

Sincerely,

William S. Heffelfinger

William S. Heffelfinger

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

HEALTH AND
ENVIRONMENT

10 OCT 1973

Mr. Wilbur D. Campbell
Assistant Director
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Campbell:

This responds to your letter of September 14, 1973 to Secretary Schlesinger which forwarded a draft report entitled "Study of Federal Water Pollution Research and Demonstration Programs," Case B-166506, for information and comment. Although the report does not contain any recommendations directed to the Department of Defense, we do have several observations and comments.

1. General

a. In regard to the recommendation that EPA assume the lead agency responsibility "for developing and implementing a national water pollution R&D plan...aimed at establishing an integrated, systematic, comprehensive approach to the federal water pollution R&D efforts," DoD will be pleased to cooperate with EPA and other concerned agencies in the formulation and execution of such a plan. It is suggested that such a plan include a systems analysis which would consider costs/benefits of the various national goals and an analysis of available technology to insure that realistic goals are developed in a proper priority and then research funding be in consonance with these priorities.

b. In regard to the recommendation that OMB "establish criteria and procedures for the transmittal of all water pollution R&D technical reports...to the designated focal point," it is suggested that any system developed should use existing systems such as NTIS and supplement them rather than establish a completely new system.

c. Throughout the report the Corps of Engineers (Corps) is referred to in tables and in the text separately from the Department of Defense. The report should be corrected to reflect that the Corps of Engineers is a Department of the Army agency under the Department of Defense. The fact that Corps of Engineers Civil Works funds are appropriated by Congress directly to the Secretary of the Army might be noted parenthetically or by footnote reference. Specific references that should be corrected are:

(1) Vol I, p 86-87, p 141.

(2) Vol I, p 138. (Discussion of DoD, as well as all of App III, omit discussion of Corps of Engineers role which is considered significant.)

(3) Enclosure C, p 39, 40.

d. In the discussions on land treatment (Incl B, p 33, and Vol II, p 81, 109) the wastewater management studies for Chicago, Detroit, and Cleveland are classified as "research." The studies are feasibility studies that examine alternative procedures that are available within the current state-of-the-art and are not "research" in accordance with the accepted definition of the term. They are planning studies that systemize the alternatives and their implications; choice is left to local governing bodies.

e. The report contends that there is conflicting opinion between the Corps and EPA regarding the land treatment option. With respect to land treatment, both EPA and the Corps now agree that is is a viable alternative and that it is environmentally sound. (This opinion was most recently voiced by Stanley M. Greenfield, Assistant Administrator for Research and Monitoring, EPA, at the National Symposium on Ultimate Disposal of Wastewaters and their Residuals held at Durham, N.C., April 26-27, 1973.) With respect to the scale of land treatment sites, both agencies now agree that determination of the most desirable alternative technology should await the detailed planning studies for each specific site. The scale of application of the land treatment alternative is important and planners must consider whether the conditions at each particular site are amenable to design, construction, and operation of this technology. Both EPA and the Corps agree that land disposal and other alternatives should be considered on a case by case basis to select the most cost effective solution to individual problems.

2. Specific

a. Volume I, p 97-98. While these statements were correct during earlier phases of the Corps of Engineers studies, they are no longer correct. Beginning in May 1973 and continuing to the present time, the Corps has actively participated in a series of meetings with EPA, USDA, land-grant Universities and others to improve coordination of research activities. The Corps' efforts in this regard follow:

(1) In May 1973, several Corps officials met with EPA representatives at the Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma, to exchange information on land treatment research in the respective agencies.

(2) In July 1973, Corps personnel participated in a research needs workshop, sponsored by EPA, USDA, and land-grant Universities to establish research needs and priorities for recycling sewage effluent and sludges to the land. Proceedings of this workshop are scheduled for publication later this year.

(3) Officials of the Agricultural Research Service (USDA) and the Corps met in Beltsville, Maryland, in August 1973 to exchange information on on-going research activities and to explore ways of fostering closer coordination between the agencies. The Corps and ARS have a cooperative research study on land treatment and agronomic practices in progress at St. Paul, Minnesota.

(4) A technical research workshop on land treatment of wastewater was held at the US Army Cold Regions Research and Engineering Laboratory, Hanover, in September 1973 to review the progress to date of Corps land treatment research. In additon to Corps personnel, participants in the workshop included representatives of EPA, Agricultural Research Service, U.S. Geological Survey, Office of Water Resources Research (Department of the Interior), U.S. Army Medical Department, and academic personnel from several universities involved in land treatment research.

(5) Corps representatives have actively supported and participated in deliberations of the newly formed Federal Interagency Committee on Recreational Waste Management. The nature and scope of research and development projects of the U.S. Forest Service and others, including work on land treatment, are pursued through this committee.

b. Volume II, p 117. Wastes from Watercraft. All Corps of Engineers floating plants operating on the Great Lakes requiring marine sanitation facilities were equipped with total retention systems prior to FY 1973.

c. Enclosure B, p 35.

(1) To minimize confusion, the terminology "conventional treatment" should be defined in terms of secondary treatment or advanced waste treatment.

(2) There is some indication, from bids received on new construction starts, that the actual construction cost of large (over 100 mgd) advanced waste treatment plants may considerably exceed the costs estimated in the Chicago study.

d. Enclosure B, p 36.

(1) The paragraph entitled "Limited applicability of soil treatment systems" presents a narrow view of the applicability and

potential of land treatment systems and apparently is based on the number of systems currently in operation. The land treatment alternative should be viewed in the context of meeting the goals and objectives of PL 92-500 while presenting unique opportunities for recycling and reuse.

(2) This last paragraph implies that conventional waste treatment systems are infallible which is a common misconception of the state-of-the-art of advanced waste treatment process design and dependability of plant operation.

(3) A preface to the paragraph on "Limited application...." should indicate whether these are conclusions by EPA or the General Accounting Office.

e. Enclosure C, p 45. Section 123(i), River and Harbor Act of 1970 (PL 91-611) authorized the Chief of Engineers under the direction of the Secretary of the Army to "extend to all navigable waters, connecting channels, tributary streams, other waters of the United States and waters contiguous to the United States, a comprehensive program of research, study and experimentation relating to dredge spoil. This program shall be carried out in cooperation with other federal and state agencies...." Phases I and II of a 4-phase study, involving problem identification and assessment and research program development, were undertaken in June 1971 and a final report was completed in November 1972. Preparation of this report involved extensive contact and coordination with EPA and other interested federal and state agencies. Phase III, the research stage of the program was initiated in March 1973. Since that time, extensive contacts have been made with many federal and state agencies, universities, and private research firms. In August 1973, a comprehensive briefing was held for interested federal agencies at which details of the Corps program were presented in an effort to stimulate interests in coordinated research efforts. Since this briefing, further contacts have been made with designated officials of various agencies to further cooperative efforts. There has been considerable interagency contact in this study to date, and the future program proposes expenditure of considerable efforts to develop cooperative programs and avoid any undesirable redundancy of research.

Sincerely,

George J. Hayes

George J. Hayes
Major General, MC USA
Principal Deputy

GAO note: Page references refer to a previous draft report and are not applicable to this report.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

October 10, 1973

Mr. Morton E. Henig
Associate Director
Manpower and Welfare Division
General Accounting Office
Washington, D. C. 20548

Dear ~~Mr. Henig~~ Mort:

This is in response to your letter of September 14, 1973, transmitting copies of the draft report "Study of Federal Water Pollution Research and Demonstration Programs" (B-166506).

We found the report informative and believe many points identified for research may be helpful to NSF directorates. The following comments on the NSF portion of the report are provided for your consideration.

Volume I:

The figure for 1972 given on page 141 is 2332(000), although the data previously reported was 5932. Total figures given on pages 141 and 13 should be 10,887.

Page 138, last line, add, "lakes and rivers." after "oceans."

Volume II:

Page 112 - Change to read, "NSF funds Great Lakes research related to water pollution through its research programs, carried out primarily at universities and non-profit organizations. The bulk of this research was in support of IFYGL."

Enclosure A - Page 88 - The 1969 expenditures for NSF should be 155 instead of -0-. This would change the total to 712.

We appreciate the opportunity of commenting on the report.

Sincerely yours,

T. E. Jenkins
Assistant Director
for Administration

GAO note: Page references refer to a previous draft report and are not applicable to this report.

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

October 26, 1973

Mr. John Landicho
Assistant Director
General Government Division
U.S. General Accounting Office
441 G Street, N. W.
Washington, D. C. 20548

Dear Mr. Landicho:

This is in reply to your letter of September 14, 1973 requesting comments on the draft report entitled "Study of Federal Water Pollution Research and Demonstration Programs."

We have reviewed the attached comments of the National Oceanic and Atmospheric Administration, National Technical Information Service and the Deputy Assistant Secretary for Environmental Affairs and believe they are appropriately responsive to the matters discussed in the report.

Sincerely yours,

Turner

Henry B. Turner
Assistant Secretary
for Administration

Attachments

DEPARTMENT OF COMMERCE

NOAA COMMENTS ON DRAFT GAO REPORT ON THE STUDY OF FEDERAL WATER POLLUTION RESEARCH AND DEMONSTRATION PROGRAMS
(B-166506)

We have reviewed the subject draft particularly in the light of our responses of December 1972, and May 1972, for the GAO Audit of Environmental Research and Developmental Activities. We have the following comments:

We are unable to confirm the precise figure of $6,416K given on page 13 and page 141 of Volume I as NOAA's obligations or expenditures for water pollution R&D during FY 1971-73. However, this figure is in the vicinity of estimates derivable from our above responses.

In the table on page 87 of Volume I, we believe that crosses should be added for NOAA under the research areas of mining and agriculture.

We believe that the discussion, on page 94 of Volume I and pages 85-87 of Enclosure A, of the relationship between programs of EPA's West Kingston, Rhode Island laboratory and DOC's Milford, Connecticut laboratory should be amplified in the interest of current accuracy. We suggest the addition of the following sentence at the end of the last paragraph on page 94 of Volume I, "Coordination efforts have been initiated." On page 87 of Enclosure A we suggest that the order of the first and second paragraphs be reversed; the first sentence of the present first paragraph be deleted; and the following paragraph be added after the first and second paragraphs.

"Most recently the laboratory Directors and principal investigators of Milford and West Kingston met to discuss the research activities of the two laboratories. A mechanism was established for better coordination of the research programs of the laboratories. It was agreed that periodic meetings would be made to ensure that the programs remain non-duplicative, but complementary."

In the table on page 83 of Volume II, IFYGL is omitted from the DOC column although it is cited on page 81 as one of the organizations through which NOAA carries out its efforts.

We believe that IFYGL should be included in this table with a cross for each research area except the last one, alternative waste treatment methods.

On page 108 of Volume II, IFYGL is omitted from the second paragraph, which states the organizations under which NOAA efforts are concentrated. We believe IFYGL should be included in that paragraph. Correspondingly, we believe that a short paragraph describing IFYGL, similar to those describing Sea Grant and the Lake Survey Center, should be included in the section on DOC on pages 108 and 109 of Volume II. We volunteer the following paragraph for that purpose.

"NOAA was designated as lead agency of the IFYGL in 1971. This program, planned initially under the International Hydrologic Decade, involves an intensive field program to collect data on the physical, chemical, and biological characteristics of Lake Ontario. Analysis of these data and the development of simulation models is part of the IFYGL program. This analysis effort is aimed at the understanding of the lake as a physical, chemical, and biological interactive system and providing resource managers with information useful in their decision-making process. It is expected that the information developed for Lake Ontario will be applicable to solving problems in the other Great Lakes."

In the table on page 41 of Enclosure C we believe that crosses should be added for NOAA under the program elements of transportation, agriculture, mining, and oil and hazardous material spills. We do not distinguish between light industry and heavy industry in NOAA's activities and do not understand why NOAA is designated under light industry and not under heavy industry in this table.

As a result of review discussions between NOAA personnel and GAO personnel, a modified figure of $ 5.4 million has been agreed upon to replace the figure of $6.3 million given on pages 80 and 81 of Volume II as the DOC level of water research in the Great Lakes Basin in FY 1972.

GAO note: Page references refer to a previous draft report and are not applicable to this report.

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
Washington, D.C. 20230

OFFICE OF THE DIRECTOR

September 28, 1973

Mr. John Landicho
Assistant Director
General Government Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Landicho:

This is in response to your letter of September 14, 1973, to Secretary Dent on the Comptroller General's draft report to the Congress on the "Study of Federal Water Pollution Research and Demonstration Programs". My comments are limited to Chapter 5 of the report which deals with the dissemination of research information and is of particular interest to the National Technical Information Service.

The report specifically cites the Water Resources Scientific Information Center, the Smithsonian Science Information Exchange, and the National Technical Information Service as major information sources in the water pollution field and discusses lack of coordination between these services. The report, however, fails to note the availability of the joint NTIS-SSIE search service through which a requester can obtain access to the complete files of both organizations through a single query addressed to either organization. This joint search service, which began in April 1973, provides convenient single point-of-contact access to all of the on-going research information in the SSIE files and all of the completed research report information in the NTIS files. The report also fails to note that NTIS processes all of the WRSIC bibliographic information, as a contractor to WRSIC, and that all of the WRSIC research reports are available from NTIS. There is, in fact, extensive coordination and cooperation between these organizations.

I agree with the basic finding of the report that a strong central focal point within the Federal Government for coordinating water pollution research information sources would be desirable. I do not agree, however, that the focal point, WRSIC in the example used in the report, should perform the functions of collecting, storing, and disseminating water pollution research information. This would lead to unnecessary duplication of the functions of the already existing central services--NTIS and SSIE. Any deficiencies in these existing central services, such as out of date or incomplete information, should be corrected in the central service for information in all disciplines and not just for water pollution research information.

The report recognizes the importance of the information analysis function to technology transfer and recommends the increased use of Information Analysis Centers. I agree with this approach, but note that the establishment of these Centers does not necessarily lead to aggressive, active information dissemination. NTIS provides an active marketing service for nearly 20 Information Analysis Centers sponsored by such agencies as DoD, AEC, NASA, and Commerce. A central focal point, such as WRSIC, to coordinate the activities of Information Analysis Centers in this field seems entirely appropriate but we would urge that the existing facilities and services of NTIS be utilized for the marketing and dissemination of the products and services of these Centers.

Accordingly, although I agree with most of the conclusions of the report, I do not agree with the specific recommendations as stated in the draft.

Sincerely,

Peter F. Urbach
Acting Director

DEPARTMENT OF COMMERCE

COMMENTS OF THE DEPUTY ASSISTANT SECRETARY FOR ENVIRONMENTAL AFFAIRS ON GAO DRAFT REPORT ON THE STUDY OF FEDERAL WATER POLLUTION RESEARCH AND DEMONSTRATION PROGRAMS

(B-166506)

We cannot agree with the statement made on page 100, Vol. 1, concerning industry's reluctance to provide information. On the contrary, industry has been extremely generous in providing the Federal government with scientific, technical and economic data and information. This information has been provided directly to EPA, the Department of Commerce and other appropriate agencies, as well as by means of the many reports which had been generated by the National Industrial Pollution Control Council, now terminated. The only reluctance which industry has exhibited has been with regard to information of a proprietary nature, the divulgence of which would have an unfavorable impact on individual companies.

GAO note: Page references refer to a previous draft report and are not applicable to this report.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OCT 9 1973

Mr. Edward A. Densmore, Jr.
Assistant Director
Resources and Economic Development
  Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Densmore:

Thank you for the opportunity to comment on the draft reports titled "Study of Federal Water Pollution Research and Demonstration Programs - Volume I" and "Cleaning America's Inland Seas: Study of Federal Water Pollution Research and Demonstration Programs on the Great Lakes - Volume II."

Because of our limited involvement, we have no general comments on the overall report. I should note, however, that NASA has cooperated with the Environmental Protection Agency in our activities related to water pollution R&D and will continue to do so in the future.

With respect to NASA's involvement in the Great Lakes program, I recommend that the paragraph on page 112 of Volume II describing NASA's involvement be altered to read as follows:

> "NASA's involvement in Great Lakes water pollution research is one of providing assistance to other governmental agencies if requested. Using its expertise in remote sensing from spacecraft and aircraft, NASA develops the technique for data collection and analysis on projects requested or sponsored by other agencies. Although NASA's past involvement in the Great Lakes has been minimal, the use of its capabilities and data could play a much larger role in the future. In particular, NASA's Lewis Research Center, Cleveland, Ohio, has recently responded to a request from EPA by submitting to them a draft plan for a Great Lakes baseline/trend monitoring system."

Sincerely,

Bernard Moritz
for Richard C. McCurdy
Associate Administrator for
Organization and Management

GAO note: Page references refer to a previous draft report and are not applicable to this report.

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE
37902

TVA
40TH
ANNIVERSARY
OF PEOPLE IN
PARTNERSHIP

October 3, 1973

Mr. Wilbur D. Campbell
Assistant Director
Resources and Economic Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Campbell:

This refers to your September 14, 1973, letter to Mr. Wagner.

We have reviewed the draft report to Congress on your study of Federal water pollution research and demonstration programs. Our only comment concerns a statement that appears on page 90 of Volume 1, which states ". . . This agreement, however, is not applicable to other agencies who are also conducting thermal pollution research." While it is true that the agreement is not applicable to other agencies, we believe this statement is misleading and could be interpreted by some that the cooperative agreement between EPA and TVA to study the effects of heated water at Browns Ferry Nuclear Plant was made without considering the interests or research carried out by other agencies. This is not the case. While the agreement, per se, involves only EPA and TVA, the concept for this project was developed with the understanding that the research would be coordinated with related research of other agencies and that the information obtained would be highly useful and applicable to program interests of other agencies. Staff of the Atomic Energy Commission have expressed much interest in the research work planned at Browns Ferry, and technical staff from TVA have discussed program objectives and other aspects of the project with research staff at ORNL now engaged in a laboratory scale research on effects of heated water on fish. The EPA-TVA project will be coordinated with the ORNL project and other related research projects to assure that duplication of effort is avoided and that results will be complementary.

We appreciate the opportunity to review the draft report.

Sincerely yours,

Lynn Seeber
Lynn Seeber
General Manager

GAO note: Page references refer to a previous draft report and are not applicable to this report.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

OCT 5 1973

Mr. Gregory J. Ahart
Director, Manpower and
  Welfare Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Ahart:

The Secretary asked that I respond to your letter of September 14, which requested our views and comments on a General Accounting Office draft report on Federal water pollution research and demonstration programs.

While we have no comments to make, we appreciate having had the opportunity to review this report before its publication.

Sincerely yours,

James B. Cardwell
Assistant Secretary, Comptroller

DEPARTMENT OF STATE
Washington, D.C. 20520

October 30, 1973

Mr. Frank C. Conahan
Associate Director
International Division
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Conahan:

I am enclosing Department of State comments on Volume II of the General Accounting Office study of Federal Water Pollution Research and Demonstration Programs on the Great Lakes. This is in response to your letter of September 21, 1973, to then Acting Secretary of State Kenneth D. Rush.

The Department appreciates the opportunity to review and comment upon the draft report.

Sincerely yours,

Richard W. Murray

Richard W. Murray
Deputy Assistant
Secretary for
Budget and Finance

Enclosure

DEPARTMENT OF STATE COMMENTS ON VOLUME II OF GAO STUDY OF FEDERAL WATER POLLUTION RESEARCH AND DEMONSTRATION PROGRAMS ON THE GREAT LAKES

The draft report was reviewed in the Department's Bureau of International Scientific and Technological Affairs. We welcome the effort to facilitate a wider understanding of the needs of this important matter.

The Department has no substantive comments regarding the content of the report. We would suggest however that its utility would be enhanced were it to be drafted with the following three objectives in mind:

(1) To bring to the attention of the Congress the need for improved research coordination and increased funding for the research on the Great Lakes pollution problems.

(2) To provide a comprehensive listing of institutional mechanisms and research activities on Great Lakes problems.

(3) To identify areas where research effort is needed to best meet, with limited funding, effective solutions to the pollution problems of the Great Lakes.

The Department would recommend that the recent report of the Great Lakes Research Board to the International Joint Commission (IJC) be taken into consideration in preparing the final report. It is our understanding that the IJC has provided a copy of the report.

JVN Granger
John V.N. Granger
Acting Director

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N. W.
WASHINGTON, D. C. 20006

October 26, 1973

Dear Mr. Densmore:

Thank you very much for sending us a draft of your report to the Congress on the Federal Water Pollution Research and Demonstration Program under Section 5 of the 1972 Amendments to the Federal Water Pollution Control Act.

Our staff has not had time to review your comprehensive report in exhaustive detail, but on the basis of our examination we find it a comprehensive and thorough effort and have no comments to offer at this time on its conclusions and recommendations.

Sincerely,

Steven D. Jellinek
Acting Staff Director

Mr. Edward A. Densmore, Jr.
Assistant Director, Resources
and Economic Development Division
General Accounting Office
Washington, D. C. 20548

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING

ENVIRONMENTAL STUDIES BOARD
2101 CONSTITUTION AVENUE
WASHINGTON, D.C. 20418

October 1, 1973

Mr. Thomas N. Medvetz
Supervisory Auditor
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Medvetz:

As I mentioned in our telephone conversation today, I am sending my review comments on the report to the Congress on the GAO study of Federal water pollution research and demonstration programs, a copy of which Mr. Henry Eschwege sent to Dr. Philip Handler on September 14, 1973. The focus of my examination of the draft was on the accuracy of references to the Academy and its reports. Although I was able to identify most of the Academy reports mentioned it would be extremely difficult for anyone outside the Academy to locate these reports on the basis of the information given in the GAO draft. Furthermore, it is not always clear which Academy report is referred to. It might be helpful to include complete bibliographic information in the form of footnotes.

I have noted several errors in references made to Academy reports:

Vol. I, pp 34-35. The Committee on Water Quality Criteria in its report Research Needs in Water Quality Criteria identified eight high-priority subject areas, not six as stated in your report. They are 1) organic compounds, 2) metals, 3) bioaccumulation and concentration factors, 4) interactions of pollutants, especially ~~for~~ metals and organic chemicals, 5) ecosystem analysis, 6) relationships between microbial water quality and human health, 7) improved methodologies of research and 8) baseline data on water quality and monitoring of natural conditions and levels of pollutants.

Vol. I, p. 70. The "green book," Water Quality Criteria was written by the National Technical Advisory Committee, not by the Academy, and it was published by the Government Printing Office for the Department of the Interior, not EPA.

Vol. I, p. 71. The GAO report is in error in its chronology of the delays in the revision of Water Quality Criteria. Our contract required that a draft report be submitted to EPA in December, 1971. This draft was in the hands of EPA on time on December 1, 1971. We were to allow EPA 60 days for comments; however, the first comments were not submitted to NAS until March, 1972, and they continued through June, 1972. (NOAA provided the only timely and worthwhile review comments on the December, 1971 draft). Our final draft was submitted to EPA on July 22, 1972, before the contract deadline. EPA did not have to approve the content of this or any other Academy report. EPA did, however, have to approve the printing of the report by GPO. A manuscript was prepared for printing and was delivered to EPA on August 28, 1972, and on time. EPA then submitted additional comments to the Academy to which we responded with revisions in the manuscript. These revisions were completed in December, 1972. Delays in printing resulted when EPA lost the artwork done by GPO, and when EPA misplaced the manuscript after the type had been set but before the galleys were proofed. EPA's proofreaders tried unsuccessfully to proof the galleys against an outdated copy of the manuscript.

Enclosure A, p. 17. The NAS report referred to is not identified.

Enclosure A, p. 22. See comments on Vol. I, pp. 34-35.

Enclosure A, p. 36. The 1970 report was written by the National Academy of Sciences Committee on Oceanography and by the National Academy of Engineering Committee on Ocean Engineering, not by the Panel on Marine Aquatic Life and Wildlife of the Committee on Water Quality Criteria.

Enclosure A, p. 83. See comments on Vol. I, p. 71.

I would also like to make a few comments on parts of the GAO report not relating directly to NAS activities.

Vol. I, p. 2a, l 8-9. "the three most significant municipal water pollution problems" are not identified here but should be.

Vol. I, p. 6. GAO recommends R&D efforts on "less - costly municipal waste treatment processes." This statement needs clarification. I assume that the meaning is ~~or~~ less costly than the advanced processes now being developed, but the phrase could also be taken to mean less costly than current technology.

Vol. I, p. 41, last paragraph. Although it is true that the chemical reactions involved in phosphorous removal have been known for many years, there were many practical problems that needed to be worked out in applying this technology.

Mr. Thomas N. Medvetz
October 1, 1973
Page Three

Enclosure A, p. 32. Last line should read 5,000 gallons of water, not 500.

I hope these comments have been helpful. If you have any questions please feel free to call me at 961-1806.

Sincerely yours,

J Charles Baummer Jr.

J. Charles Baummer, Jr.
Staff Officer

GAO note: Page references refer to a previous draft report and are not applicable to this report.

SMITHSONIAN INSTITUTION
Washington, D.C. 20560
U.S.A.

OCT 9 1973

Mr. O. Gene Abston
Assistant Director
General Government Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Abston:

Thank you for the opportunity to review a copy of Volume 1 of your report entitled Study of Federal Water Pollution Research and Demonstration Programs B166506. As your report points out, Federal programs in water pollution span a wide range of Federal Agencies. We feel, and your report substantiates the fact, that coordination of this effort can be enhanced. We feel the problem is not so much one of the information necessary for coordination not being available but rather that, as you suggest, no common focal point exists to insure coordination and use of existing systems.

I would like to offer the following specific comments regarding the Smithsonian Science Information Exchange (SSIE) which is referred to in Volume 1.

We feel the first sentence in paragraph 1 on page 117 to wit: "Currently there is no expedient method by which a user can identify from any one central source the water pollution research that is being done throughout the Federal Government", is not quite true. The SSIE can provide this information if, as the sentence says, you are referring to "research that is being done" since the Exchange's holdings in the area of water pollution are believed to be reasonably complete if not fully complete. This would not be true in all areas of science but, because of the Exchange's designation by the President (PM 1766) as the cataloging center for active research, and because a catalog on water resources is prepared annually by SSIE for publication by the Office of Water Resources Research, we feel research in this area is reasonably complete. To substantiate this we note that the number of Federally supported projects in water resources rose from 1,545 in 1965 to 6,010 in the 1973 edition of the Water Resources Research Catalog.

The sentence beginning at the bottom of page 117 and continuing on page 118 to wit: "A further problem noted was that none of the information systems were complete or comprehensive in coverage. For instance SIE collects data on active research only, while NTIS concerns itself only with reports of completed research", implies that either or both of these organizations should have both types of data. Since neither agency is authorized to collect the same type of data the other has, it is not surprising that they do not have each other's data base since this would be a classic example of unwarranted duplication. SSIE and NTIS have a written agreement which provides a mechanism for users of either service to obtain information from both data bases through either organization at a price less than the cost of going to either separately, although in some cases we have recommended that users go to the separate systems for certain types of questions where one or the other of the data bases has no information. The present state of interrogation in both systems makes it unnecessary to develop the concept of having both data bases in one location. Quite often, user needs require information from only one or the other data base; as separate data bases the cost to the user is thus less. The next sentence on page 118 starting "although agencies are ...", again refers to the fact that SSIE's data are incomplete. Our comment here would be to refer to our statement made above showing the increase in water resources research registered at SSIE.

In reference to the data files of individual agencies we note the comment by GAO on page 119, first sentence at the top of the page which says, "For example the data in these systems was often not current or complete, and the systems were oriented to individual agency missions." We would like to note that this comment emphasizes one of the major advantages of a centralized data center for ongoing research to retrieve information rather than going directly to individual agencies. Specifically, a centralized data center such as SSIE indexes research projects received from all sources strictly on the basis of their subject content rather than on any preconceived concept that orients projects into or out of subject areas regardless of the content of the research summary. In short, all projects dealing with water resources research would be indexed the same regardless of which agency they originated from. The indexing would also be uniformly accomplished and not be subject to individual thesauri terms of each agency.

We see no problem in the suggestion proposed by GAO for designating WRISIC as the focal point for dissemination and utilization of research information if, as proposed, WRISIC would continue to make use of SSIE rather than try to duplicate or maintain the file on current research now held by SSIE since this data is readily available to WRISIC. In fact, the plan as envisioned should increase use of SSIE data by WRISIC, a highly desirable objective especially in preparing state of the art reports.

We would like to see the chart on page 124 amended, however, to show input from universities, contractors and industries also coming directly into SSIE, as well as through the producers of data box, since the Exchange currently receives input directly from these sources where support is other than Federal.

We have some reservations with regard to the ultimate recommendations (page 129), if as they seem to read, that a Federal focal point should be established for collecting, storing, and disseminating water pollution research information. It would seem more appropriate to designate such a Federal focal point for the purpose of coordinating the collection of, etc., and establishing criteria and procedures for the transmittal of all water pollution R&D technical reports and program information from Federal Agencies to the designated information systems (rather than the designated focal point)as the last sentence now reads. The text of the report (page 126) would seem to indicate the type of role we suggest here for the Federal focal point rather than that stated in the recommendations (page 129), i.e., a support service and/or switching terminal.

If you would like further information or clarification of any of these comments, please contact Dr. David F. Hersey (Code 144-5514) who is currently the President of the Smithsonian Science Information Exchange.

Sincerely yours,

S. Dillon Ripley
Secretary

GAO note: Page references refer to a previous draft report and are not applicable to this report.

Great Lakes Basin Commission

October 3, 1973

Frederick O. Rouse
Chairman

State of Illinois
Natural Resources Development Board
State of Indiana
Department of Natural Resources
State of Michigan
Department of Natural Resources
State of Minnesota
State Planning Agency
State of New York
Department of Environmental Conservation
State of Ohio
Department of Natural Resources
Commonwealth of Pennsylvania
Department of Environmental Resources
State of Wisconsin
Department of Natural Resources

Department of Agriculture
Department of the Army
Department of Commerce
Department of Health, Education & Welfare
Department of Housing & Urban Development
Department of the Interior
Department of Justice
Department of State
Department of Transportation
Environmental Protection Agency
Federal Power Commission
Great Lakes Commission

Mr. C. H. Moore, Regional Manager
United States General Accounting Office
Regional Office
2006 Washington Boulevard Building
234 State Street
Detroit, Michigan 48226

Dear Mr. Moore:

In response to your letter of September 19, transmitting a copy of Volume II of a draft report to the Congress on the United States General Accounting Office's study of Federal Water Pollution Research and Demonstration Programs, I would like in general to limit my remarks to the portion of the report and those topics that bear directly upon the Great Lakes Basin Commission's responsibilities and actions.

As you are probably aware, the Great Lakes Basin Commission staff assisted your investigators in developing their Great Lakes program for study by identifying agencies and individuals to be contacted, by describing basic missions of the numerous agencies involved and by providing judgmental information to the investigators. Our extensive water resources library and the services of our research librarian were made available at all times to your investigators.

The Great Lakes Basin Commission is charged by Public Law 89-80 as the principal agency responsible for coordinating all water and related land resource planning in the Great Lakes. It is also charged with recommending long range schedules of priorities for the collection and analysis of basic data, investigations and the construction of projects. In recognition of the fact that good planning rests upon the foundations of good research, the Commission with the general concurrence of the Water Resources Council has interpreted the provisions of the act relating to "investigations" to include "planning-oriented research" which

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Mr. C. H. Moore
October 3, 1973
Page Two

encompasses most of the research and demonstration projects for water quality covered in your report. It also, of course, includes all elements of research and demonstration projects other than water quality in the entire field of water and related land resources.

While we have not exhaustively analyzed the issue, there seems to be some question about EPA's responsibility under law "to develop and implement a master plan" for a comprehensive processes and effects research program for water quality in the Great Lakes. Legislation, funding and staffing more clearly in line with such a mandate would seem to be desirable.

The Office of Water Resources Research, created under the United States Water Resources Research Act of 1965, has basic responsibility for the funding of water resources research. This organization, in its current program, is looking towards regional organizations such as the Great Lakes Basin Commission to identify those regional problem areas which require additional research attention. The staff of the Great Lakes Basin Commission cooperates with the Office of Water Resources Research in reviewing specific proposals for research funding relating to Great Lakes problems. At the very low levels of funding accorded the Great Lakes Basin Commission, it is obviously ill-equipped to perform adequately this function. The same situation exists to a different degree in the Office of Water Resources Research.

As one of the efforts to assist in coordinating ongoing research within the Great Lakes Basin, the Executive Director of the Great Lakes Basin Commission staff has continuously supported the International Great Lakes Study Group and its activities. He currently is in his second year as U. S. Chairman of this group.

At no point does the draft of the General Accounting Office report indicate the relationship of water quality research to the total area of research required to solve the problems of the Great Lakes. This important aspect should at least be acknowledged in the report and an indication given for the necessity for integrating water quality research with research on water and related lands in general.

On balance, the draft of the report appears to be generally adequate. It is somewhat lengthy and to a degree repetitive. However, later drafts will undoubtedly sharpen up the presentation. My review does not indicate any particular distortions or fact or interpretation. The weighing of the interpretation is subject to considerable discussion, however. The draft mentions the Great Lakes Basin Commission on pages 86 and 87 and the International Great Lakes Study Group on page 87. The statements regarding these two organizations are substantially correct and factual.

Mr. C. H. Moore
October 3, 1973
Page Three

The United States General Accounting Office might well consider recommending the assignment of the coordination of all water and related land resources research to the Great Lakes Basin Commission in connection with the necessity for properly relating water quality and general research. This would ideally fit in with the principal coordinating responsibility of the Great Lakes Basin Commission in other water and related land resource activities. This would seem to be a logical designation in view of the fact that all agencies having any significant responsibility with respect to water and related land in the Great Lakes Basin are members of the Basin Commission.

While the Great Lakes Basin Commission is required by law to operate on a consensus principle, the Chairman of the Great Lakes Basin Commission, a presidential appointee, is in the absence of a consensus charged also by law, with responsibility for stating the position of the Chairman, acting in behalf of the Federal members on all matters before the Commission. Consequently, the authority for coordination is already established in the position of the Chairman of the Great Lakes Basin Commission.

The opportunity to review your report in draft form is sincerely appreciated. The Basin Commission, as always, is ever ready to assist in coordination and support of other activities which will improve the efficiency and effectiveness of water and related land resources conservation, utilization and development of the Great Lakes Basin. If I can be of any further assistance to your organization at any time in the future, please feel free to call upon me.

Sincerely yours,

Leonard T. Crook

Leonard T. Crook
Executive Director

INTERNATIONAL JOINT COMMISSION
UNITED STATES AND CANADA
WASHINGTON, D.C. 20440

October 16, 1973

Mr. Frank C. Conahan
Associate Director
United States General
Accounting Office
Washington, D. C. 20548

Dear Mr. Conahan:

This is in response to your letter of September 21, 1973, requesting the International Joint Commission's review and comment on the General Accounting Office's report "Cleaning America's Inland Seas: Study of Federal Water Pollution Research and Demonstration Programs on the Great Lakes."

Because of our small staff and the many pressing matters before the Commission at the present time, we have been unable to give your report a detailed review. However, we have noted the reference to the Great Lakes Water Quality Agreement and the Commission's responsibilities with respect to that Agreement, including the coordination of Great Lakes water quality oriented research between Canada and the United States.

During the first week in October, the Commission met in a semi-annual session in Ottawa and at that time received a report from its Great Lakes Research Advisory Board on "Research Needs: Great Lakes Water Quality." The Commission agreed to make the report public and transmit copies to Governments and public and private agencies, which might have an interest.

A copy of this report is enclosed for your information and use, as you may deem appropriate.

Sincerely,

John F. Hendrickson

John F. Hendrickson
Executive Director
United States Section

Enclosure

CHRONOLOGY OF EPA AND ITS PREDECESSOR AGENCIES RESPONSIBLE FOR FEDERAL WATER POLLUTION R&D PROGRAMS

1948--Division of Water Pollution Control established in the Department of Health, Education, and Welfare.

1954--Division of Water Pollution Control reduced to a branch and consolidated with other divisions into the new Division of Sanitary Engineering Services.

1959--Water Pollution Control Branch and other water pollution research and technical functions became the Division of Water Supply and Pollution Control.

1960--Division of Water Supply and Pollution Control grouped with other divisions to form the environmental health segment of the Bureau of State Services, Public Health Service.

1961--Research and training grants responsibilities under the control of the National Institutes of Health transferred to the Division of Water Supply and Pollution Control.

1965--Division of Water Supply and Pollution Control became the Federal Water Pollution Control Administration, a separate administration in the Department of Health, Education, and Welfare.

1966--Federal Water Pollution Control Administration transferred to the Department of the Interior in accordance with Reorganization Plan No. 2.

1967--Federal Water Pollution Control Administration reorganized.

1968--Federal Water Pollution Control Administration reorganized.

1970--Federal Water Pollution Control Administration became the Federal Water Quality Administration.

1970--Federal Water Quality Administration transferred to EPA in accordance with Reorganization Plan No. 3.

1971--R&D functions of the Water Quality Office and other appropriate research activities of the Agency became the Office of the Assistant Administrator for Research and Monitoring.

1972--Water Supply Programs Research Division transferred to the Office of the Assistant Administrator for Research and Monitoring.

1973--Office of the Assistant Administrator for Research and Monitoring reorganized and became the Office of the Assistant Administrator for Research and Development.

FEDERAL FUNDING FOR WATER POLLUTION R&D PROGRAMS

Fiscal year	EPA	Other Federal agencies	Total
	(000 omitted)		
1969	$ 49,851	$ 36,390	$ 86,241
1970	45,122	40,294	85,416
1971	52,024	54,598	106,622
1972	49,121	70,780	119,901
1973	41,949	54,527	96,476
Total	$238,067	$256,589	[a]$494,656

[a] This may not represent the total effort of these agencies. We were unable to determine exact funding levels because agencies (1) used differing terminology to classify their R&D effort or (2) did not keep detailed figures on water-pollution-related R&D in their accounting records. Fiscal year 1973 funds are estimates.

SUMMARY OF FEDERAL WATER POLLUTION R&D EXPENDITURES BY AGENCY

Agency or Department	FISCAL YEAR					
	1969	1970	1971	1972	1973	Total
	(000 omitted)					
EPA	$49,851	$45,122	$ 52,024	$ 49,121	$41,949	$238,067
Department of the Interior:						
Bureau of Land Management	198	173	178	171	109	829
Bureau of Mines	473	651	805	1,501	-	3,430
Bureau of Reclamation	81	396	410	613	491	1,991
Bureau of Sport Fisheries and Wildlife	444	437	532	1,191	1,523	4,127
Geological Survey	6,108	7,044	8,704	9,805	10,075	41,736
Office of Saline Water	9,379	8,868	8,605	9,538	5,500	41,890
Office of Water Resources Research	4,235	3,545	4,124	5,178	5,238	22,320
	20,918	21,114	23,358	27,997	22,936	116,323
Department of Agriculture:						
ARS	3,865	4,389	7,121	8,070	7,885	31,330
Cooperative State Research Service	888	1,093	1,162	1,378	1,455	5,976
Economic Research Service	114	112	153	230	325	934
Forest Service	2,140	2,072	2,162	2,432	2,403	11,209
	7,007	7,666	10,598	12,110	12,068	49,449
AEC	6,183	6,449	7,827	7,687	9,483	37,629
Department of Transportation:						
Federal Highway Administration	13	42	211	182	567	1,015
United States Coast Guard	656	2,105	3,251	5,171	5,970	17,153
	669	2,147	3,462	5,353	6,537	18,168
DOD:						
Department of the Air Force	29	120	246	289	-	684
Department of the Army	-	-	463	657	-	1,120
Corps of Engineers	92	205	382	1,475	1,080	3,234
Department of the Navy	-	45	2,208	5,301	-	7,554
	121	370	3,299	7,722	1,080	12,592
National Science Foundation	915	1,239	2,803	5,932	-	10,889
Department of Commerce:						
National Oceanic and Atmospheric Administration	-	-	1,755	2,238	2,423	6,416
Department of Housing and Urban Development	497	1,171	645	310	-	2,623
National Aeronautics and Space Administration	80	138	309	1,114	-	1,641
Tennessee Valley Authority	-	-	460	317	-	777
Department of Health, Education, and Welfare	-	-	82	-	-	82
Total	$86,241	$85,416	$106,622	$119,901	$96,476	[a]$494,656

[a] This may not represent the total effort of these agencies as we were unable to determine exact funding levels because agencies (1) used differing terminology to classify their R&D effort or (2) did not keep detailed figures on water-pollution-related R&D in their accounting records. Fiscal year 1973 funds are estimates.

EPA AND OTHER FEDERAL AGENCIES' IN-HOUSE AND

EXTRAMURAL FUNDING FOR WATER POLLUTION R&D PROGRAMS

FISCAL YEARS 1969-73

Fiscal year	EPA		Other Federal agencies		Total	
	In-house	Extramural	In-house	Extramural	In-house	Extramural
1969	$ 4,955	$ 44,896	$ 15,662	$ 20,728	$ 20,617	$ 65,624
1970	10,939	34,183	18,273	22,020	29,212	56,203
1971	12,333	39,691	28,066	26,532	40,399	66,223
1972	16,234	32,887	36,318	34,463	52,552	67,350
1973	14,934	27,015	30,110	24,417	45,044	51,432
Total	$59,395	$178,672	$128,429	$128,160	[a]$187,824	[a]$306,832

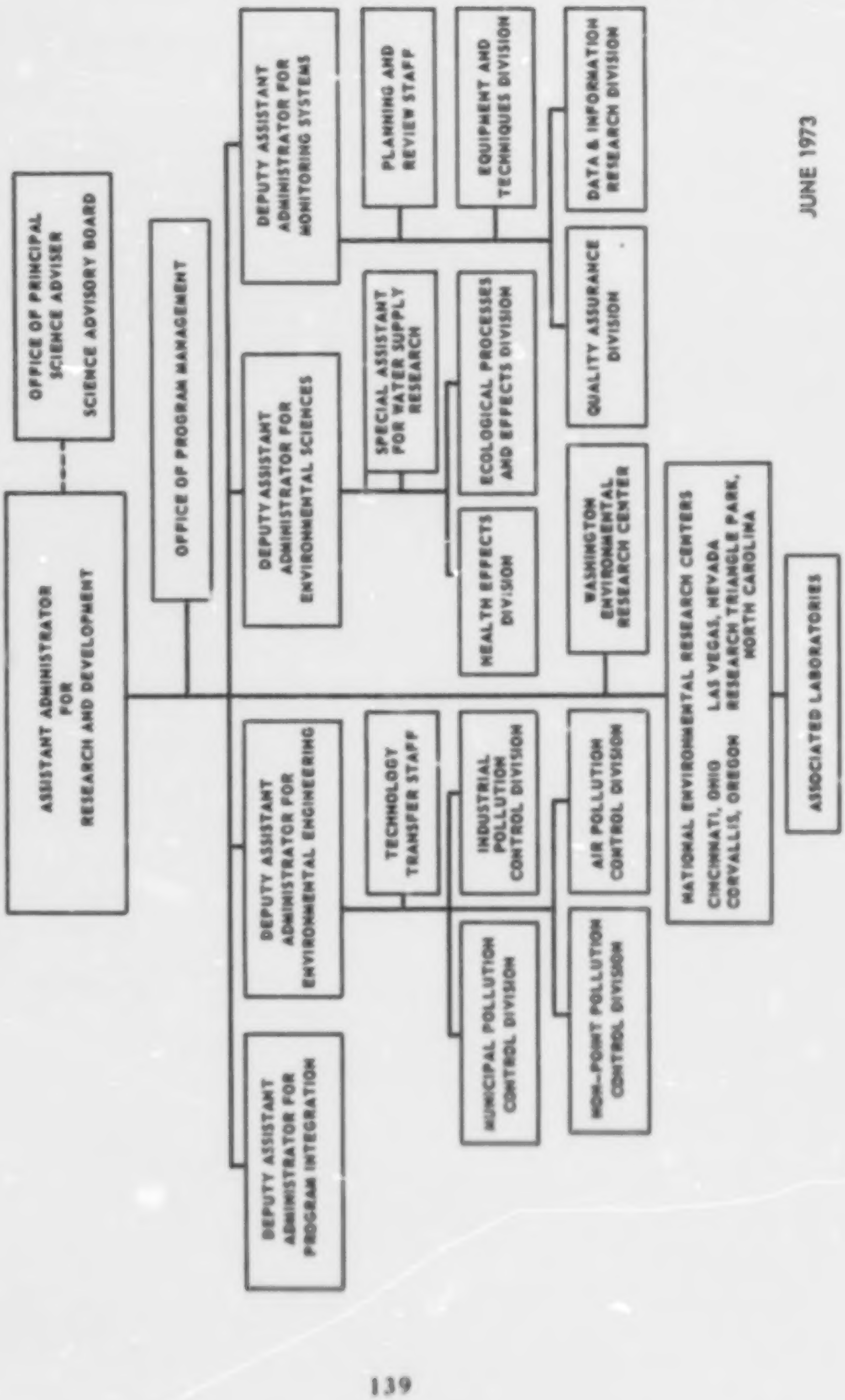
[a] This may not represent the total effort of these agencies as we were unable to determine exact funding levels because agencies (1) used differing terminology to classify their R&D effort or (2) did not keep detailed figures on water-pollution-related R&D in their accounting records. Fiscal year 1973 funds are estimates.

EPA'S IN-HOUSE AND EXTRAMURAL FUNDING
FOR WATER POLLUTION R&D BY EPA CATEGORIES
FISCAL YEARS 1969-73

Research categories	1969	1970	1971	1972	1973	Total
	(000 omitted)					
Processes and effects:						
In-house	$ 2,301	$ 5,003	$ 5,301	$ 8,330	$10,964	$ 31,899
Extramural	5,818	5,462	7,449	8,752	8,951	36,432
Total	8,119	10,465	12,750	17,082	19,915	68,331
Municipal technology:						
In-house	1,837	3,596	3,695	3,662	3,867	16,657
Extramural	22,471	14,934	15,457	9,139	5,615	67,616
Total	24,308	18,530	19,152	12,801	9,482	84,273
AST:						
In-house	817	2,340	3,337	4,189	-	10,683
Extramural	14,696	13,160	15,826	14,041	[a]11,542	69,265
Total	15,513	15,500	19,163	18,230	11,542	79,948
Other:						
In-house	-	-	-	53	103	156
Extramural	1,911	627	959	955	907	5,359
Total	1,911	627	959	1,008	1,010	5,515
Total:						
In-house	4,955	10,939	12,333	16,234	14,934	59,395
Extramural	44,896	34,183	39,691	32,887	27,015	178,672
	$49,851	$45,122	$52,024	$49,121	$41,949	$238,067

[a] Amount represents both in-house and extramural funding. Individual amounts were not available.

EPA
OR&D ORGANIZATIONAL CHART


ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
OFFICE OF PRINCIPAL SCIENCE ADVISER
SCIENCE ADVISORY BOARD
OFFICE OF PROGRAM MANAGEMENT
DEPUTY ASSISTANT ADMINISTRATOR FOR MONITORING SYSTEMS
PLANNING AND REVIEW STAFF
EQUIPMENT AND TECHNIQUES DIVISION
DATA & INFORMATION RESEARCH DIVISION
QUALITY ASSURANCE DIVISION
DEPUTY ASSISTANT ADMINISTRATOR FOR ENVIRONMENTAL SCIENCES
SPECIAL ASSISTANT FOR WATER SUPPLY RESEARCH
ECOLOGICAL PROCESSES AND EFFECTS DIVISION
HEALTH EFFECTS DIVISION
WASHINGTON ENVIRONMENTAL RESEARCH CENTER
NATIONAL ENVIRONMENTAL RESEARCH CENTERS
CINCINNATI, OHIO
CORVALLIS, OREGON
LAS VEGAS, NEVADA
RESEARCH TRIANGLE PARK, NORTH CAROLINA
ASSOCIATED LABORATORIES
DEPUTY ASSISTANT ADMINISTRATOR FOR ENVIRONMENTAL ENGINEERING
TECHNOLOGY TRANSFER STAFF
INDUSTRIAL POLLUTION CONTROL DIVISION
AIR POLLUTION CONTROL DIVISION
MUNICIPAL POLLUTION CONTROL DIVISION
NON-POINT POLLUTION CONTROL DIVISION
DEPUTY ASSISTANT ADMINISTRATOR FOR PROGRAM INTEGRATION

JUNE 1973

MISSIONS AND OBJECTIVES OF SIX FEDERAL AGENCIES WITH SIGNIFICANT WATER POLLUTION R&D ACTIVITIES

Department of the Interior

In support of their operational missions, seven bureaus or offices in the Interior conduct R&D programs that relate directly to water pollution problems.

OWRR

OWRR's mission is to stimulate, sponsor, provide for, and supplement present programs for conducting research, investigations, and experiments and for training scientists in the field of water resources research. OWRR provides annual funds to one water resource research institute in each State and in Puerto Rico. It also operates a water resources scientific information center for disseminating information on current research projects.

Geological Survey

The Survey was established to classify public lands and examine the geological structure, mineral resources, and products of the national domain. Its R&D is oriented to understanding hydrologic principles which are applicable to water pollution problems, including identification of pollutants, the sources and effects of pollution, ultimate disposal of wastes, and water quality control.

Bureau of Mines

The Bureau administers regulatory programs to stimulate private industry to produce an appropriate and substantial share of the national mineral and fuel needs in a manner that best protects the public interest. To accomplish its mission, the Bureau conducts water-pollution-related R&D on mineral wastes and it funds projects concerning environmental problems of the mineral industries.

Office of Saline Water

This Office is authorized to do R&D to find ways for economically producing, from sea and other saline water,

water suitable for agricultural, municipal, industrial, and other beneficial uses.

Bureau of Land Management

The Bureau's mission is to classify, manage, and dispose of public lands and their resources according to the principles of multiple-use management. The Bureau supports water-pollution-control-related research to expand its activities in such areas as soil and watershed management, range management, wildlife habitat management, forest management, resource protection, recreation, lands and minerals, and program development.

Bureau of Reclamation

The Bureau's mission is to locate, construct, operate, and maintain works for storing, dividing, and developing waters for the reclamation of arid and semiarid lands in the Western States. Its research includes investigations and development of plans for regulating, conserving, and using water and related land resources and also includes administering water research programs to develop maximum use of resources.

Bureau of Sports Fisheries and Wildlife

The mission of this Bureau is to perpetuate the use and enjoyment of the Nation's sportfish and wildlife resources. The water pollution research on fish, conducted by the Division of Fishery Research, covers the nutritional and disease factors that affect hatchery-raised fish and the factors that affect their survival and growth. The Division of Wildlife Research provides biological facts from which procedures and guidelines can be devised for propagating and managing wildlife populations. The Bureau, through the Division of Federal Aid, also funds research on fish and wildlife conducted by State and local agencies.

Department of Agriculture

Agriculture is directed by law to acquire and disseminate useful information on agricultural subjects. Four of Agriculture's services--the Agricultural Research Service, Cooperation State Research Service, Economic Research Service, and Forest Service--are conducting water-pollution-related R&D programs to support their missions. Some of the areas they cover are developing wise management practices for conservation and efficient use of natural resources, including research to prevent and control runoff, erosion, and drainage; solving pollution problems caused by animal wastes; and determining the polluting effects of pesticides.

AEC

AEC is responsible for developing, using, and controlling atomic energy, including the construction of nuclear power plants. It is doing R&D on thermal discharges, methods of controlling thermal discharges, and the effects of radionuclides in water, to gain basic information needed to assess health and safety in nuclear operations and protection of the environment.

R&D is also carried out on the treatment and disposal of all types of radioactive waste effluents which result from various nuclear fuel cycle operations, i.e., mining and milling nuclear materials, uranium conversion and enrichment, fuel fabrication, nuclear power plants, and fuel reprocessing.

Department of Transportation

Two components are conducting water-pollution-related R&D programs in the Department of Transportation.

Coast Guard

The Coast Guard is responsible for enforcing Federal laws on the high seas and navigable waters of the United States and its possessions and for saving life and property in and around these navigable waters. To support its mission, the Coast Guard is concentrating its R&D on controlling oil pollution in ocean and inland waters.

Federal Highways Administration

The Administration provides leadership and programs for developing a highway transportation system that effectively satisfies national, regional, and local requirements for transportation. The Administration is doing research on reducing the environmental hazards to water resource due to the highway system and the prevention of soil erosion.

DOD

One objective of DOD's research is to insure that an adequate technological base is available for national defense needs. DOD is responsible for doing such research as necessary to define and study environmental pollution problems associated with military requirements, including chemical and weapons systems. DOD's water pollution areas relate to treatment of waste water from military installations and prevent oil pollution from naval vessels and facilities.

Corps of Engineers, Department of the Army

The Corps is responsible for improving rivers, harbors, and waterways for navigation, flood control, and related purposes, including shore protection. It also administers laws for the protection and preservation of the navigable waters of the United States.

Its R&D effort consists of studying the environmental impact of dredging operations and developing alternative waste water treatment systems.

National Science Foundation

The purpose of the Foundation is to strengthen research and education in the U.S. sciences. It sponsors water-pollution-related research on weather modification, environmental aspects of trace contaminants, regional environmental systems, and the biological effects of pollutants on oceans, lakes, and rivers.

UNITED STATES GENERAL ACCOUNTING OFFICE

REPORT TO THE CONGRESS

Cleaning North America's Inland Seas: Study Of Federal Water Pollution Research And Demonstration Programs On The Great Lakes

B-166506

Volume II

Environmental Protection Agency

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

GLOSSARY

Advanced sewage treatment	The use of chemical, electrochemical, carbon filtration, or other procedures to achieve a high degree of removal of pollutants.
Algae	Relatively simple unicellular or multicellular aquatic plants, such as seaweeds and pond scums.
Combined sewers	Carry both sanitary sewage and storm water runoff. During dry weather, combined sewers usually carry all the waste water to the treatment plant. During a storm, only part of the mixed flow is carried to the plant due to overloading; the rest is discharged, untreated, into waterways.
Ecological effects	The effects of pollutants on living organisms other than man.
Ecology	The study of the interrelations of animal and plant organisms with one another and with their environment.
Effluent	The waste water discharged by an industry or municipality.
Environment	The sum total of all physical, chemical, and biological factors that may influence organisms.
Eutrophication	The process whereby a lake becomes overfertilized from too many nutrients, especially phosphorus and nitrogen. As a result, algae and other plant life become overabundant, and the lake may evolve into marshland.
Ground water	Water found underground in porous rock strata and soils, such as a spring.
Health effects	The effects of pollutants on man.

Limnology	The study of the physical, chemical, and biological characteristics of freshwaters.
Nutrients	Elements or compounds essential as raw materials for organism growth and development; e.g., carbon, oxygen, nitrogen, and phosphorus.
Primary treatment	The first stage in waste water treatment which uses screening and sedimentation techniques to remove about 30 percent of the biochemical oxygen-demanding wastes.
Secondary treatment	Using biological processes to accelerate the decomposition of sewage. Efficient treatment will reduce the biochemical oxygen demand in waste water by 80 to 90 percent.
Sediment	Any matter that settles to the bottom of a liquid.
Transport processes	The chemical and physical factors associated with sources, pathways, persistence, and fates of pollutants in the environment.
Water pollution	Manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water.
Thermal pollution	Degradation of water quality by the introduction of a heated effluent, which is primarily a result of the discharge of cooling waters from industrial processes, particularly from electrical power generation. Even small deviations from normal water temperatures can affect aquatic life.

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ABBREVIATIONS

AEC	Atomic Energy Commission
BSF&W	Bureau of Sport Fisheries and Wildlife
EPA	Environmental Protection Agency
FWPCA	Federal Water Pollution Control Administration
GAO	General Accounting Office
IFYGL	International Field Year on the Great Lakes
IJC	International Joint Commission
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
OMB	Office of Management and Budget
R&D	research, pilot, development, and demonstration

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

CLEANING NORTH AMERICA'S INLAND
SEAS: STUDY OF FEDERAL WATER
POLLUTION RESEARCH AND
DEMONSTRATION PROGRAMS ON THE
GREAT LAKES B-166506
VOLUME II

DIGEST

WHY THE STUDY WAS MADE

GAO reviewed Federal water pollution research and demonstration programs carried out in the Great Lakes Basin to assess their

--effectiveness,

--coordination with other R&D programs, and

--conflicts.

This basin is the largest mass of freshwater in the world, and a resource of immense value to the United States and Canada.

The Environmental Protection Agency (EPA) is the Federal agency primarily responsible for water pollution research, pilot, development, and demonstration (R&D) activities for the Great Lakes.

Seven other Federal agencies, several Canadian agencies, and various other groups are involved in R&D directly or indirectly related to Great Lakes water pollution.

During fiscal year 1972, EPA spent $4.5 million for R&D in the Great Lakes Basin, and the other Federal agencies spent about $10.6 million.

FINDINGS AND CONCLUSIONS

EPA at present cannot answer fully the question: What measures would effectively remedy Great Lakes pollution problems?

EPA has improved its understanding of water pollution in the Great Lakes through its R&D programs and has developed technology to control it.

Much remains to be done as shown in the four major sections to follow.

1. *Processes-and-effects research*

   EPA's research has not produced enough detailed knowledge about Great Lakes' pollutants--their sources, fate, and effects--because EPA did not carry out a comprehensive research program specifically for the Great Lakes. Instead, it relied on its national research programs, which had only limited applicability to the Great Lakes.

Recognizing the need for more effective research, EPA in 1972 undertook two research programs for the Great Lakes.

Under one of these--a long-term program--EPA is participating with other Federal and Canadian agencies in certain research on the lakes.

Under the other--a short-term program--EPA substantially reduced its scope in 1973 due to changes in priorities. This will mean further delays in acquiring the detailed knowledge needed to effectively control pollution in the lakes. (See pp. 16 to 24.)

2. *Technology development*

The Federal Water Pollution Control Act, as amended, authorizes or requires R&D specifically for the Great Lakes and authorizes projects to demonstrate better pollution control methods in the Nation at large, including the Great Lakes.

In addition, amendments enacted in 1970 authorized EPA to carry out a specific program to demonstrate new methods and to develop preliminary plans for controlling Great Lakes pollution. With regard to the 1970 law, EPA has prepared a plan but has not completed any demonstration projects under this program because of

- --late funding for the program in fiscal year 1971,
- --time required to develop a plan in fiscal year 1972 to carry it out, and
- --funding limitations imposed by the Office of Management and Budget in fiscal year 1973 which delayed the program until fiscal year 1974.

EPA's R&D programs have developed technology that could alleviate two major Great Lakes problems--combined sewer overflows and phosphorus discharges--caused by municipal sources.

However, few Great Lakes cities have applied this technology because of its high cost and/or the lack of sufficient Federal construction grant funds for treatment plants.

Two other problems--nitrogen discharges and disposal of treatment plant sludge--remain unsolved and need more research. (See pp. 28 to 38.)

The Federal Water Pollution Control Act Amendments of 1972 call for reducing water pollution substantially from industrial sources and established a national goal of eliminating the discharge of pollutants into navigable waters by 1985.

GAO's review of EPA's R&D as it relates to industries that contribute significantly to Great Lakes water pollution showed that:

- --Technology has been developed that achieves the zero discharge goal for one industry (sugar beet processing), but its economic feasibility is questionable.
- --Improved technology has been demonstrated for several industries, and the technology has been applied widely in at least two Great Lakes States.
- --However, further efforts are needed if Great Lakes industries are to reduce pollution substantially as called for by the 1972 amendments. (See pp. 38 to 42.)

3. *Many agencies, much information, but little coordination*

Seven other Federal agencies besides EPA, each pursuing its own mission, did research related to water pollution in the Great Lakes Basin. Since 1956, the Federal Water Pollution Control Act, as amended, has required EPA to promote coordination of water pollution R&D.

EPA, however, has not exercised the leadership and initiative necessary to bring about a coordinated Federal effort to meet Great Lakes water pollution research needs. As a result, research has not provided as much knowledge about Great Lakes pollution as it could have. (See pp. 43 to 49.)

4. *International aspects of research*

In 1972 the United States and Canada entered into a Great Lakes Water Quality Agreement. The agreement empowered the International Joint Commission to help coordinate and evaluate all Great Lakes water pollution activities, including research. This action could lead to more comprehensive and coordinated research, but because the Commission is dependent on governmental organizations and others for research facilities, funds, and corrective actions, it cannot insure a coordinated research effort.

If the U.S. contribution under the agreement is to be effective, Federal agencies' programs must be sound and the agencies must be willing and able to coordinate them.

These factors underscore the need for EPA to initiate and carry out a comprehensive Great Lakes processes-and-effects research program and exercise leadership in improving coordination of Federal water pollution research on the lakes. (See pp. 50 to 59.)

RECOMMENDATIONS

The Administrator, EPA, should

--begin and carry out a comprehensive Great Lakes processes-and-effects research program aimed at determining the sources, quantity, dispersion, fate, and effects of pollutants, and

--exercise leadership, in cooperation with the International Joint Commission, in improving the coordination of Federal water pollution research on the Great Lakes.

EPA's R&D programs for solving municipal and industrial water pollution problems are carried out on a nationwide basis. GAO's recommendations on those programs are in volume I of this report and would, of course, help solve these problems with respect to the Great Lakes. (See p. 59.)

AGENCY COMMENTS

In September 1973 drafts of this report were submitted to EPA, the Great Lakes Basin Commission, and the International Joint Commission. These agencies were in general agreement with our report. Their comments are contained in volume I, appendix II. EPA stated that it is doing its best to provide leadership to a coordinated Great Lakes water pollution research effort but that it did not have the resources and/or authority to adequately coordinate Federal research on the Great Lakes. (See p. 59.)

MATTERS FOR CONSIDERATION BY THE CONGRESS

Matters discussed in this volume should be of a particular interest to the Congress in its deliberations on future water pollution control programs.

CHAPTER 1

PERSPECTIVE

> "The water pollution problems of the Great Lakes are myriad and complex. But the will to do something about it is strong. Ways will be found."[1]

The Great Lakes--Erie, Huron, Michigan, Ontario, and Superior--are of immense value to the United States and Canada. Because of them, a heavy concentration of population and industry in the Great Lakes Basin enjoys an almost unlimited supply of water, low-cost transportation, scenic beauty, and beaches along 11,000 miles of shoreline.

But man's pollution threatens the lakes. In less than 150 years man has brought changes in the lakes that probably would have taken centuries under natural conditions.

The Congress has expressed concern about the progress of Federal research, pilot, development, and demonstration (R&D) programs in solving the Nation's water pollution problems. In the Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251 note (Supp. II, 1972)), the Congress directed us to study and assess

--the efficacy of such programs,

--their coordination, and

--conflicts between them.

Our study results are contained in a two-volume report with three supporting enclosures. Volume I summarizes our study of Federal water pollution R&D programs. In this volume we summarize the results of our study of R&D programs on the Great Lakes.

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[1] "Water Pollution Problems of the Great Lakes Area," Federal Water Pollution Control Administration, Great Lakes Region, Department of the Interior, September 1966 (revised Oct. 1967).

SCOPE OF STUDY

We concentrated on activities of the Environmental Protection Agency (EPA) because that agency is primarily responsible for water pollution R&D for the Great Lakes. We reviewed other Federal agencies' R&D activities to identify their research efforts and to determine the adequacy of interagency coordination.

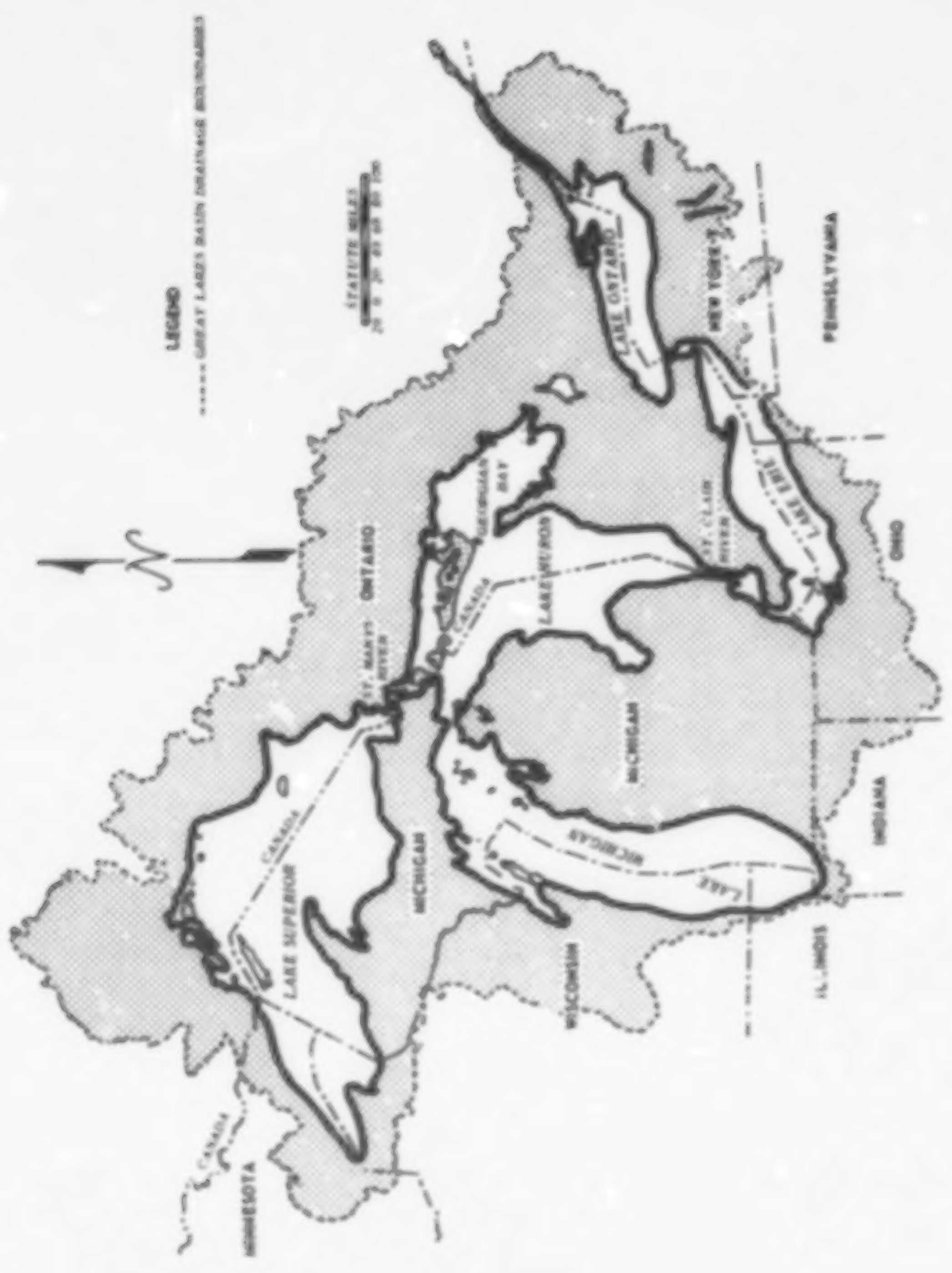
We examined Federal agencies' documents, records, studies, and other pertinent literature. We interviewed officials at Federal agencies' headquarters, Great Lakes offices, and laboratories; Canadian agencies; State and local agencies; and other organizations in the Great Lakes Basin. (See app. I.) Also, we visited various R&D projects in the basin. (See app. II.) To assist us in the review, we employed consultants with expertise in various disciplines of environmental science and engineering, including specialists in Great Lakes water research.

THE GREAT LAKES--KEYS TO A CONTINENT

The lakes (see map on p. 7) comprise the world's greatest reservoir of freshwater. They have a larger total area--95,000 square miles--than England, Scotland, Wales, and Northern Ireland combined. Moreover, since the St. Lawrence Seaway was completed in 1959, these inland seas have been open to ocean shipping. The Great Lakes-St. Lawrence River system provides a waterway reaching almost 2,000 miles from the Atlantic to nearly the midpoint of the North American continent at Duluth, Minnesota.

The Great Lakes Basin is one of North America's most important regions. It supports about 35 million people and involves the jurisdictions of the United States and Canada. It encompasses all of Michigan and parts of Illinois, Indiana, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and the Province of Ontario.

For many decades the region has been referred to as the industrial belt of the Nation. Its industry accounts for almost one-fourth of the Nation's total manufacturing activity and employs about one-fourth of the manufacturing work force.


LEGEND
GREAT LAKES BASIN DRAINAGE BOUNDARIES
STATUTE MILES
25 0 25 50 75 100
N
MINNESOTA
CANADA
LAKE SUPERIOR
CANADA
MICHIGAN
ST. MARYS RIVER
ONTARIO
WISCONSIN
LAKE MICHIGAN
MICHIGAN
ILLINOIS
INDIANA
LAKE HURON
CANADA
GEORGIAN BAY
ST. CLAIR RIVER
OHIO
LAKE ERIE
PENNSYLVANIA
NEW YORK
LAKE ONTARIO

The Great Lakes are the region's lifeblood. They:

--Supply its population with 4 billion gallons of water daily.

--Supply industry with 8 billion gallons daily.

--Supply water for electrical power.

--Serve as highways for shipping grain, iron ore, manufactured goods, and other commodities. To illustrate the volume of lake shipping, the canal connecting Lakes Superior and Huron carries a greater annual tonnage of shipping than the Panama Canal.

--Support important commercial and sport fisheries.

--Serve as playgrounds for countless pleasure seekers. For example, 44,000 acres of parks and beaches are along the shores of Lake Erie.

The future growth of the Great Lakes region depends to a great extent on an adequate quality of water. Thus, it is imperative that the water resources of the lakes not be degraded.

POLLUTION--A THREAT TO THE LAKES

Unfortunately, the viability of the Great Lakes is by no means assured. Their quality has continuously deteriorated because of pollution--years of uncontrolled waste discharges have taken their toll. As a result, some areas are like this:

UNSAFE
FOR
SWIMMING

Instead of like this:

EPA PHOTOGRAPHS

In general, the quality of any lake directly reflects the density of population and the industrial concentration in its drainage basin. For that reason the water quality of the lakes varies widely. The Great Lakes ranked from worst to best in water quality are:

--Lake Erie
--Lake Ontario
--Lake Michigan
--Lake Huron
--Lake Superior

Appendix III summarizes the condition of each lake.

CHAPTER 2

WATER POLLUTION R&D IN THE GREAT LAKES BASIN

R&D is a vital part of the battle against water pollution. Briefly, R&D seeks to provide solutions to problems. The Federal Water Pollution Control Act, as amended in 1956, authorized a variety of R&D activities to help combat pollution in the Great Lakes. Over the last decade, EPA and its predecessor agencies have been responsible for these activities. Many other parties--Federal and non-Federal, in both the United States and Canada--have also carried on research related to Great Lakes pollution.

FEDERAL WATER POLLUTION CONTROL ACT

The act, as amended, authorizes or requires R&D specifically for the Great Lakes and authorizes projects to demonstrate better pollution control methods in the Nation at large, including the Great Lakes.

Specific provisions for the Great Lakes were added in 1961 and 1970. The 1961 additions required:

--An analysis of the present and projected future water quality under varying conditions of waste treatment and disposal.

--An evaluation of the water quality needs of those to be served by the waters.

--An evaluation of municipal, industrial, and vessel waste treatment and disposal practices on the lakes.

--A study of alternate means of solving pollution problems, including more waste treatment measures.

The 1970 additions authorized Federal agreements with any State or public agency to carry out projects to (1) demonstrate new methods and techniques and (2) develop preliminary plans for eliminating or controlling pollution in all or any part of the lakes' watersheds.

In addition, the act indirectly provides for Great Lakes demonstration activities because it authorizes Federal grants to any State, municipality, intermunicipal or interstate agency, or person--regardless of geographic location--for projects to demonstrate better methods for controlling designated kinds of pollution. For example, such projects are to demonstrate

--new or improved methods of controlling the discharge of untreated or inadequately treated sewage from sewers which carry storm water or both storm water and sewage,

--advanced waste treatment and water purification methods or new or improved methods of treating municipal and industrial wastes jointly, and

--industrial prevention of water pollution.

FEDERAL AGENCIES PRIMARILY RESPONSIBLE FOR IMPLEMENTING THE ACT

Since 1961 several agencies have been primarily responsible for carrying out the provisions of the act. The sequence is summarized below.

--From 1961 to 1966 the responsibility rested with two units of the Department of Health, Education, and Welfare: the Public Health Service (1961-65) and the Federal Water Pollution Control Administration (FWPCA) (1965-66).

--In May 1966 FWPCA was transferred to the Department of the Interior and in April 1970 was renamed the Federal Water Quality Administration.

--In December 1970 the functions of the Federal Water Quality Administration were transferred to EPA.[1] EPA was established for the purpose of rationally and systematically organizing the Federal Government's environmentally related activities.

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[1] In this report, unless otherwise stated, references to EPA include EPA and its predecessor agencies. (See app. III, vol. I.)

During fiscal years 1969-73 EPA spent about $238 million nationally for water pollution R&D projects. Fiscal year 1972 and 1973 expenditures were $49 million and $42 million, respectively. We could not estimate the amount of these funds EPA spent for the Great Lakes because EPA records do not designate those projects which have applicability to Great Lakes problems. Moreover, as explained in more detail below, not all projects in the Great Lakes Basin itself are conducted solely to meet the Great Lakes' needs.

During fiscal years 1969-72 EPA spent about $32 million on R&D projects in the basin; fiscal year 1972 expenditures were about $4.5 million. During these years EPA funded 120 research projects and 73 demonstration projects. As the following table shows, outside organizations did most of the work under grants and contracts.

EPA R&D Expenditures in the Great Lakes Basin

Fiscal Years 1969-72

Organizations	Expenditures		
	Research	Demonstration	Total
	(millions)		
EPA laboratories (in-house)	$ 4.9	$ -	$ 4.9
Universities (grants and contracts)	3.4	0.7	4.1
Industry (grants and contracts)	2.7	8.0	10.7
Municipalities (grants and contracts)	0.5	11.0	11.5
Other	0.8	0.2	1.0
Total	$12.3	$19.9	$32.2

Not all of the projects in the basin were aimed solely at Great Lakes needs. For example, of 12 EPA funded projects at the University of Michigan, 7 addressed general, rather than exclusively Great Lakes, water pollution problems.

EPA's research facilities in the basin include two laboratories, the National Water Quality Laboratory in Duluth and the Grossee Ile Laboratory in Grosse Ile, Michigan. The two laboratories do some in-house research and administer grants and contracts under the direction of EPA's National Environmental Research Center at Corvallis, Oregon. In addition, EPA's Office of Research and Development has representatives in the EPA region V office in Chicago who administer grants and contracts but do not perform any in-house research.

OTHER FEDERAL AGENCIES DOING WATER RESEARCH

Besides EPA, seven Federal departments or independent agencies are doing research related to water pollution on the Great Lakes. The agencies are the:

Atomic Energy Commission (AEC)
Department of Commerce
Department of Defense
Department of the Interior
Department of Transportation
National Aeronautics and Space Administration (NASA)
National Science Foundation (NSF)

In fiscal year 1972, the agencies spent about $10.6 million for water research in the Great Lakes Basin. A brief description of the agencies' water research programs is in appendix IV.

NON-FEDERAL WATER RESEARCH ACTIVITIES

The States in the Great Lakes Basin also conduct or support water research. In addition, various colleges and universities in the region do water research using their own as well as Federal, private, and industrial funds. Some of these institutions have Great Lakes centers; the major ones include the University of Michigan Great Lakes Research Division, the University of Wisconsin Center for Great Lakes Studies, the Great Lakes Laboratory of the State University College at Buffalo, New York, the Ohio State University Center for Lake Erie Research, and the University of Minnesota Lake Superior Limnological Research Station.

Private industry has not remained on the sidelines. We were not able to identify the full extent of its participation but, according to 1 scientific journal, at least 17 private corporations are directly connected with Great Lakes research.

The power industry, for example, has funded various projects to determine the effects of thermal pollution on the lakes.

CANADIAN ACTIVITIES

In Canada, both the National and Ontario Governments conduct research on Great Lakes pollution. The headquarters for national research is in the Canada Centre for Inland Waters, Burlington, Ontario. The Centre, created in 1967, is a major research establishment of the Department of the Environment. Ontario does research through the Ontario Ministry of the Environment, Toronto, a provincial agency created in 1957. The Great Lakes Division of the University of Toronto also does research.

CHAPTER 3

EPA NEEDS TO KNOW MORE ABOUT PROCESSES AND EFFECTS OF WATER POLLUTANTS

EPA's research into the processes and effects of water pollutants has identified general pollution problems of the Great Lakes but has not produced enough detailed knowledge about the pollutants' sources, quantity, dispersion, fate, and effects.

As a result, EPA and State agencies do not have an adequate basis for

--setting and enforcing sound water quality standards,

--predicting how proposed technical methods of abating pollution will affect water quality, and

--evaluating how applied technical methods have affected water quality.

THE ROLE OF PROCESSES-AND-EFFECTS RESEARCH

Processes-and-effects research seeks to identify or determine pollutants'

--major sources;

--nature and quantity;

--transfer, dispersion, reactions, and ultimate fate; and

--effects on the environment.

The research is intended to provide scientifically sound water quality criteria to help EPA and the States set and enforce water quality standards, review and approve discharge permits, and review and comment on environmental impact statements. Water quality standards, particularly important in pollution control, prescribe how much of a specific pollutant is allowed to be put into a body of water--how much will be tolerated.

The research also provides the detailed knowledge necessary for forecasting the impact on water quality if various levels of pollutant removal are achieved. This knowledge is essential for properly answering the question: What measures would effectively remedy our pollution problems?

EARLY RESEARCH (1961-67) IDENTIFIED THE LAKES' POLLUTION PROBLEMS

Processes-and-effects research on Great Lakes waters was required by the Great Lakes research provisions added to the Federal Water Pollution Control Act in 1961. The provisions required, among other things:

--An analysis of the present and projected future water quality of the waters under varying conditions of waste treatment and disposal.

--An evaluation of the water quality needs of those to be served by the waters.

In response to the requirements, EPA predecessor agencies made extensive studies on Great Lakes waters from 1961 to 1967. The Public Health Service of the Department of Health, Education, and Welfare studied Lakes Erie, Huron, Michigan, and Ontario from 1961 through 1965, and FWPCA continued the work through 1967.

Through the studies, data was collected on water quality, projected future water quality needs, and pollution problems, such as bacterial and chemical pollution and accelerated aging of the lakes. (The major problems identified are described in more detail in app. V.) Federal and State agencies used some of the data to set limits on pollutant discharges and to establish pollution abatement schedules for Lakes Erie, Ontario, and Michigan.

The early studies were extensive and useful, but EPA and university research officials advised us the studies were only the beginning step toward acquiring a thorough knowledge of the processes and effects of pollutants in the lakes; much more detailed follow-on studies were needed.

RESEARCH SINCE 1967 HAS NOT PROVIDED NEEDED SCIENTIFIC DATA

From 1968 to 1972, EPA and its predecessor agencies did not carry out a research program specifically for the Great Lakes and therefore did not make the more detailed studies needed. Instead, they relied on national programs to provide information on the processes and effects of pollutants. Much of the information developed under the national programs, however, had only limited applicability to the Great Lakes. Consequently, EPA does not have the knowledge it needs about Great Lakes pollutants.

National programs did not meet Great Lakes research needs

From 1968 until 1972, the research efforts of the agencies responsible for carrying out the Federal Water Pollution Control Act were largely piecemeal and sporadic because they were not effectively coordinated and directed toward common objectives and goals. Agencies conducted projects on the Great Lakes only if the projects met the agencies' national R&D needs. The agencies established national needs and priorities by consolidating lists of regional research needs sent in by the regional offices.

During fiscal years 1969-72, $7 million of the $32.2 million EPA spent on R&D projects in the Great Lakes Basin was for processes-and-effects research, of which $5.6 million was for studies of ecological effects. The research, however, was directed primarily at meeting national rather than specifically Great Lakes needs.

The ecological effects research was funded primarily through EPA's National Water Quality Laboratory at Duluth. This research was intended to provide scientifically sound water quality criteria for the Nation, to help EPA and the States carry out their responsibilities to

--set and revise water quality standards,

--enforce water quality standards,

--review and approve discharge permits, and

--evaluate environmental impact statements.

Much of the information developed through national program research outside the basin had only limited application to the Great Lakes. To effectively understand and solve the lakes' problems, processes-and-effects research must be done on the lakes themselves; this is essential because the processes and effects of pollutants are affected by many factors peculiar to the specific water involved--its currents, its depth, and the variety and extent of pollutants. According to our consultant, the Great Lakes have several important peculiarities.

--Circulation pattern. The water circulation pattern of the Great Lakes tends to concentrate pollutants in near-shore areas, in contrast to the pattern in smaller lakes which tends to distribute pollutants more evenly throughout the lake. Because of this concentrating factor, pollutants in the Great Lakes tend to accumulate in larger quantities and they may have unique interactions.

--Flushing time. This is the time needed to entirely replace the body of water present at any one time. The flushing time for some of the Great Lakes is unusually long. For instance, for Lake Michigan the time is 100 years. The effect is that pollutants remain longer in the Great Lakes than they do in faster flushing lakes.

--Size. Because of the lakes' huge surface area, pollutants entering from the atmosphere are a much greater source of pollution than they are in most other bodies of water. And because the Great Lakes are so large, extensive research resources are needed to determine their degree of pollution.

The limited applicability of national program processes-and-effects research to the Great Lakes is illustrated by EPA's research on the accelerated eutrophication (aging process) of lakes--a major problem in the Great Lakes and elsewhere. During fiscal years 1969-72, EPA funded about $8 million of research into the accelerated aging process of lakes throughout the country. Fourteen projects, costing $836,000, were performed in the Great Lakes Basin; 5 of the 14 were performed on Great Lakes waters.

However, this national research did not satisfy the need for knowledge about eutrophication of the Great Lakes. For example, in a May 1971 EPA internal document, "Assessment of the Research and Monitoring Program for the Great Lakes," EPA pointed out that it did not have the technical knowledge to

--predict the movement of phosphorus or nitrogen--two nutrients that hasten the aging process--in the Great Lakes,

--assess the effectiveness of reducing either the phosphorus or nitrogen from waste discharges, or

--investigate the trade-off between nitrogen and phosphorus removal.

The Director of EPA's National Eutrophication Research Program told us the size and complexity of the Great Lakes and the many sources of nutrients and other pollutants involved make it difficult or impossible to apply to the Great Lakes much of the research information developed outside the Great Lakes. He informed us that the research done elsewhere can indirectly contribute to nutrient control and restoration programs on the lakes but cannot solve their premature aging problem. According to the Director, research aimed specifically at these complex bodies of water is necessary to understand the problem.

Why did EPA predecessor agencies rely on their national programs for information about Great Lakes pollutants? We were unable to find out why FWPCA and the Federal Water Quality Administration did so. EPA's Assistant Administrator for Research and Development told us that current EPA management does not have enough information to interpret the actions of responsible officials of these agencies. A leading university research official with experience in Great Lakes research told us that these agencies may have believed they could meet the Great Lakes' needs through research on small lakes. However, EPA has evidently recognized that the lakes' needs cannot be met by national programs only and has begun improving its research on the lakes.

In its May 1971 document, EPA made clear that a planned, systematic Great Lakes research effort was needed to enable EPA to determine the

--quantity and type of pollutants discharged by major sources,

--effects of pollutants on the ecosystem (the living organisms and the physical features of the environment),

--movements and effects of pollutants,

--feasibility and cost effectiveness of controlling pollutants, and

--extent of changes in water quality resulting from use of control procedures.

The May 1971 document also pointed out that the various Great Lakes research activities of other organizations needed to be sorted, evaluated, and placed in the framework of EPA's mission and needs.

Because EPA did not carry out a research program specifically for the lakes, many Great Lakes research needs which FWPCA identified in 1968 are still considered needs by EPA region V. In fact, region V submitted similar needs to Washington for fiscal year 1974; they are summarized below.

1. Research on phosphorus and nitrogen is needed to define the phosphorus and nitrogen cycles in the Great Lakes and the amount of nutrients contributing to the accelerated aging of the lakes. Results are to be used in connection with enforcement and water quality standards compliance programs.

2. Research on aquatic plant growth is needed to determine the causes of increased aquatic plant growth and the relation of the growth to oxygen depletion in the Great Lakes. Results are to be used in forming recommended abatement or pollution prevention programs.

3. Research on combinations of pollutants is needed to determine the effects from combinations of pollutants. Results are to be used in developing an abatement program and supporting information for regulatory authorities.

4. Research on thermal pollution is needed to determine the local and long-term effects of thermal (heated waste water) discharges on Great Lakes ecology. Results are to be used in evaluating the adequacy of proposed pollution control technology and practices.

The effect of not having an adequate Great Lakes program was further described by the EPA region V Director of the Office of Research and Development in a Great Lakes research need statement for fiscal year 1974. He said:

> "The baseline of scientific data and information available varies considerably on the five lakes but can be generally characterized as inadequate. The problems have been characterized but the knowledge of each pollution source, the determination of the fraction of the total input of each pollutant of concern which can be attributed to each source, the loading rates, effects and impact on water quality are woefully inadequate. An assessment of the sources, loadings, water quality, and ecological effects is essential before rational water quality management decisions can be made." (Underscoring supplied.)

EPA ACTIONS TO BETTER MEET GREAT LAKES NEEDS

In July 1971, EPA's Office of Research and Development opened the Grosse Ile Laboratory. The laboratory is responsible for administering four EPA research programs, two of which--fate of pollutants in large lakes and Great Lakes research--address Great Lakes needs.

Fate of pollutants in large lakes

The purpose of the fate of the pollutant program, initiated in April 1972, is to develop a scientific basis for predicting and assessing the fate of pollutants in large lakes, such as the Finger Lakes, the Great Salt Lake, and particularly the Great Lakes. According to an EPA headquarters official, the program is oriented to meet basic, long-term Great Lakes needs.

The program has mainly supported EPA's participation in the International Field Year on the Great Lakes (IFYGL) program. In fiscal year 1972, $820,000 of the $997,000 program funding was for such participation.

IFYGL is a joint United States-Canadian study of Lake Ontario initiated by the international scientific community as a contribution to the International Hydrological Decade (1965-74). Canadian agencies and seven Federal agencies, including EPA, are participating in the study. It will serve as a pilot for studying all the Great Lakes and as a mechanism for providing information for interdisciplinary analyses of the physical, bilogical, and chemical data; issues of public concern; and water resources management needs. According to one of our consultants, the IFYGL study concept is good because it focuses research resources and many scientific disciplines on one lake at one time. He believes the study will provide valuable lessons for future research on the lakes.

All the scientific data under IFYGL had been collected by June 1973. Analysis of the data is expected to be completed in 1976, and program results are to be published in 1977. However, EPA advised us that the results of the EPA-sponsored portion of the study will generally be available in July 1974 and that the final report will be published in July 1975.

EPA's Assistant Administrator for Research and Development informed us in May 1973 that, as IFYGL commitments are met, program emphasis will shift to Lakes Erie and Michigan, and to Saginaw Bay, Michigan, and Lake Huron in support of a study by the United States-Canada International Joint Commission (IJC). IJC was requested to initiate the study by provisions of an agreement in 1972, which made IJC specifically responsible for assisting in coordinating the Great Lakes research activities of both countries. (See ch. 6.)

Great Lakes research program

This program was initiated in July 1972 to meet EPA's short-term, more immediate Great Lakes research needs. The research program was to have been funded at $1.7 million during fiscal year 1973 and was to extend through 1978 at a total cost of $12.2 million. The funds were to have been used to develop

- predictive models of chemical, physical, and biological processes affecting pollution;

- guidelines for controlling nutrients; and

- guidelines for controlling the ecological stresses caused by thermal pollution.

According to the program director, the program would have helped EPA a great deal in meeting its research needs for the lakes. But, EPA reduced the fiscal year 1973 funds to $926,000. It eliminated the research on thermal pollution and greatly reduced the research on developing predictive models. In the program director's opinion, the reduced program is not adequate.

EPA's Assistant Administrator for Research and Development told us that the funding was reduced because of changes made in priorities for a variety of reasons. EPA can reduce the program funding at its discretion because the Congress, in appropriating funds for EAP research, does not earmark funds specifically for Great Lakes processes-and-effects research.

How much would an adequate Great Lakes processes-and-effects research program cost? EPA officials with whom we discussed the point did not know. The previously cited May 1971 EPA assessment document on Great Lakes research stated that: "The cost of an effective research program cannot be specified at this time." The document indicated that a program to understand the nutrient (phosphorus and nitrogen) problem alone would cost at least $5 million to $10 million a year for several years.

CHAPTER 4

EFFORTS TO DEVELOP AND DEMONSTRATE TECHNOLOGY TO CONTROL GREAT LAKES POLLUTION

Legislation enacted in 1965 and 1966 authorized EPA to develop and demonstrate, under national programs, technology to control pollution from municipal and industrial sources. Legislation enacted in 1970 authorized EPA to carry out a specific Great Lakes technology development program.

EPA has made some progress in establishing a specific Great Lakes program and in developing technology for controlling pollution from industrial and municipal sources. But, much remains to be done.

LIMITED EPA PROGRESS IN ESTABLISHING AND CARRYING OUT A GREAT LAKES PROGRAM

In 1970 the Congress amended the Federal Water Pollution Control Act to authorize Federal agreements with any State or public agency for projects to

--demonstrate new methods and techniques and

--develop preliminary plans for eliminating or controlling pollution in all or any part of the watersheds of the Great Lakes.

The legislation authorized $20 million to be appropriated for such projects.

EPA's progress in carrying out a specific Great Lakes program has been limited because of:

--The time needed to develop a program and EPA's initial uncertainty as to how and where funds should be spent.

--Funding limitations imposed by the Office of Management and Budget (OMB).

Time and funding problems affect the Great Lakes program

EPA established a Great Lakes program and received $815,000 late in fiscal year 1971 (April). As a result, little time was available to develop a plan of action. EPA awarded three grants, totaling $740,000, for waste water management planning studies in southeastern Michigan and the Lake Erie Basin portion of Pennsylvania and for an environmental impact study in Cleveland, Ohio. None of these projects had been completed as of June 30, 1973.

In fiscal year 1972, EPA greatly reduced its request for funds and did not spend any funds because, at the time, it did not have a plan to carry out Great Lakes projects. However, EPA did hire consultants to study and recommend how funds for Great Lakes projects could best be applied.

According to the consultants' report, the 1970 legislation allows EPA to demonstrate a variety of approaches to control water pollution in the Great Lakes that are not possible under other programs. The report stated that the legislation implicitly recognizes that the approaches available in other programs may not be adequate for controlling pollution in a large and complex basin such as the Great Lakes Basin. The consultants' view was that $20 million in demonstration projects, by themselves, would have little impact on the pollution problems besetting the Great Lakes. But, they concluded that the program would be meaningful in attacking Great Lakes pollution if it was judiciously used "to develop a short and long term strategy that has some opportunity of coming to grips with the massive issues involved." Their report included recommendations on projects that EPA should conduct under the program.

On the basis of the consultants' recommendations, EPA, during fiscal year 1973, initiated three demonstration projects involving $1.8 million in Federal funds. Since the projects were in progress as of June 1973, we could not evaluate their results. However, if they achieve their objectives, they could lead to new methods and plans for controlling pollution in the Great Lakes. A brief explanation of each project follows.

- --One grant was awarded to East Lansing, Michigan, for a 2-year demonstration and evaluation of a biological waste treatment system. The system includes disposal of waste waters by spraying them on cultivated and forest land and waste water reuse. The objective is to provide an alternative method of advanced waste treatment.

- --The second grant was awarded to the Michigan Water Resources Commission for a 5-year monitoring and evaluation of land disposal of waste waters in Muskegon County. The project deals specifically with using waste waters for spray irrigation of cultiviated land. One objective is to obtain data needed for developing regulations for using spray irrigation systems. According to EPA, the project should answer many of the questions posed by State and local regulatory agencies regarding the effects of such systems, including effects on public health.

- --The third grant was awarded to the Allen County, Indiana, Soil and Water Conservation District. It involves a 4-year planning and demonstration of techniques for reducing pollution from soil runoff in the Maumee River Basin. One of the objectives is to determine what can be done to get landowners to adopt practices to minimize water pollution from soil runoff.

In fiscal year 1973, after EPA had developed a plan and decided which projects it was going to fund, another complication arose--OMB did not release funds appropriated for the program. The Congress appropriated $4,665,000 for Great Lakes demonstration projects, but OMB released only $1,947,000.

In June 1973, at EPA's request, OMB released the remaining funds appropriated by the Congress. An EPA official told us in October 1973 that it was too late to use the funds in fiscal year 1973, and therefore, they were carried over to fiscal year 1974. He told us that EPA had made no definite decisions as to how it would use the funds.

DEVELOPING AND DEMONSTRATING TECHNOLOGY TO CONTROL POLLUTION FROM MUNICIPAL AND INDUSTRIAL SOURCES

Through its national programs, EPA has sought to develop technology to control pollution from municipal and industrial sources, which, according to State agencies, are the two major sources of water pollution in most of the Great Lakes States. The objectives of the national programs were to:

--Support the Federal construction grant program by developing and demonstrating technology to control pollution from municipal sources.

--Support Federal enforcement programs by assuring the availability of technology to control pollution from industrial sources.

During fiscal years 1969-73, EPA spent about $164 million nationally--$84 million for municipal technology and $80 million for industrial technology--to develop and demonstrate control technology relating to significant Great Lakes pollution problems. The greater part of these expenditures supported projects outside the Great Lakes Basin.

Technology to control pollution from both municipal and industrial sources has been developed under the national program. But, further technology is needed to combat Great Lakes pollution problems. Success in achieving substantial reduction of pollution from municipal sources has also been adversely affected by the lack of sufficient construction grant funds to apply the technology.

Lack of construction funds limits use of technology to control pollution caused by municipal sources

Cities are the greatest polluters of the Great Lakes. More than 80 percent of the Great Lakes Basin population live in metropolitan areas. Some of the most populous metropolitan areas of the United States--Detroit, Cleveland, Milwaukee, and Buffalo--discharge waste waters into the lakes or their tributaries.

Federal agencies' studies during the 1960s indicated that the more significant Great Lakes needs were for:

- --Methods to eliminate pollutants from storm and combined sewer overflows.
- --More efficient and economical methods of removing nutrients, especially phosphorus.
- --More efficient and economical methods for disposing of sludge--the residue that remains after waste water is treated.

During fiscal years 1966-73, EPA spent about $59.5 million for projects to meet these needs.

EPA began funding projects in the Great Lakes Basin in 1965. For fiscal years 1965-73, EPA obligated funds as follows:

Problem area	Obligations in the Great Lakes Basin
	(millions)
Combined sewer overflow	$14.3
Nutrient removal	2.1
Sludge handling and disposal	2.2
Total	$18.6

Developing technology to control combined sewer overflow discharges

Discharges from combined sewers are a major source of water pollution in the Great Lakes Basin. There are 382 Great Lakes Basin municipalities and/or sewage authorities that have combined sewer systems. Combined sewers carry domestic and/or industrial wastes at all times and, during storms or thaws, also carry storm runoff from streets and other sources. Sewers and sewage treatment facilities usually have some excess capacity but not enough to handle the increased flows that can occur during storms.

To avoid overloading the sewers and the treatment facilities, combined sewer systems generally have diversion facilities which allow part of the excess flow to be discharged directly into waterways--without treatment. These untreated discharges of sewage and storm runoff have caused:

--Lowering of water quality below Federal and State standards.

--Closure of beaches. (See p. 9.)

--Health hazards.

--Unsightly conditions in rivers, harbors, and bays because of floating sewage.

During fiscal years 1965-72, EPA initiated 22 development and demonstration projects in the Great Lakes Basin for controlling discharges from combined sewers. The total cost of the projects was $14.3 million. Our review of 11 projects costing $7.4 million showed that:

--Six had been completed. They demonstrated various methods of control: monitoring devices, storage facilities, screening devices, and rotating biological discs.

--Five were not complete. One was demonstrating the use of monitoring devices and two, the use of storage facilities. The other two were full-scale demonstrations of screening devices that had been proven successful on a small scale.

--Application of these alternatives was limited primarily to those municipalities and/or sewage authorities which participated in demonstration projects.

Applications were limited for several reasons. For one thing, States considered controlling discharges from combined sewers to be secondary to the need to install or upgrade waste water treatment facilities to control normal sewage flows. Also, the cost of applying the various alternatives is estimated to be billions of dollars, and State and local levels lacked funds to construct treatment facilities for combined sewer discharges.

Examples of projects for the various control methods and more detailed information on the limited application of these methods follow.

1. Monitoring devices

EPA awarded a $1 million grant to Detroit in February 1966 to demonstrate monitoring and remote control systems to control combined sewer overflows. This project was successful in that it demonstrated how a system receiving sewage from a large area could transfer overflows from one section of the city to another for in-system storage. City officials estimated that, during an 18-month period, the project prevented about 6 billion gallons of untreated storm water from being discharged into receiving streams. Detroit is still using the system, but it had not been applied elsewhere in the Great Lakes Basin as of April 1973.

2. Storage facilities

EPA awarded a $1.5 million grant to Milwaukee in late 1966 to demonstrate the feasibility of storing part of the combined sewer overflow until it could be treated. Overflow in one area of the city was channeled into large storage tanks, held until storm conditions subsided, and then returned to the sewer system. The tanks were able to retain 75 percent of the overflow which was returned to the system for treatment. The remaining 25 percent was not returned to the system, but it was chlorinated before being discharged into the receiving water.

The city engineer informed us that he considered the project results good. However, he indicated that using storage tanks to handle Milwaukee's total combined sewage overflow problem might not be feasible. Installing tanks in built-up areas would involve clearing land and relocating residents. Further, residents of adjacent neighborhoods might object to having sewage storage facilities near them, and the cost would be high. According to a 1971 engineering study, using storage tanks in only a small section of the metropolitan area would cost about $27.8 million. In the city engineer's opinion, a combination of techniques is needed to alleviate Milwaukee's combined sewer overflow problem--that is, storage tanks where land is available and other techniques where open land is not available.

3. Screening devices

EPA awarded a $357,000 grant in August 1969 to a private contractor in Milwaukee to test several kinds of screening techniques in a small-scale facility. The project demonstrated that a combination of screening and dissolved air flotation was an effective method of reducing the pollution caused by such overflows. However, according to a contractor official, a full-scale demonstration was necessary to convince the engineering profession and plant operators that the process should be adopted. He explained that full-scale evaluations sometimes disclose problems that small-scale demonstrations do not.

In June 1970, EPA awarded a $1.7 million grant to Racine, Wisconsin to demonstrate the process in full scale. A private contractor is conducting the project for the city. Project facilities were being constructed at the time of our review. According to a contractor official, the process, if successfully demonstrated, could have wide application.

In May 1971, EPA awarded a $1.1 million grant to Fort Wayne, Indiana, for a full-scale test of several types of screening devices, together with stabilization pond holding and chlorination, as a means of treating combined sewer overflow. The screening device demonstrated in Milwaukee on a small scale was one of the devices being tested. Project facilities were under construction at the time of our review.

4. Rotating biological discs

One of the projects we reviewed involved treating combined sewer overflows using rotating discs. The

> discs maintain a bacterial growth which can reduce most organic matter to the basic elements. The demonstration was conducted in Milwaukee by a private contractor under a $445,000 contract awarded by EPA in 1967. Although rotating discs have been used successfully in Europe, the demonstration was needed, according to a contractor officials, because the composition of waste water might differ from one locality to another and pilot studies are necessary to determine how the discs will perform in a given locality.
>
> In November 1972, the official told us that the project was successful, having removed 95 percent of the organic load from a combined sewer discharge. He said, however, that the technique had not been applied elsewhere in this country because the final report on the project had not yet been issued.

Applying combined sewer technology

Six of the eight Great Lakes States require that combined sewer discharges be controlled by 1977. The other two States also require control but specify no date for compliance. However, even though the technology is available, relatively little has been done in the Great Lakes Basin to achieve such control. The primary reasons are that other municipal treatment needs have been assigned higher priorities, installing combined sewer treatment facilities is too costly, and generally, construction grant funds have been insufficient.

The Administrator of EPA region V, which includes six of the eight Great Lakes States, said that the critical factor in implementing control technology is the massive amount of funds required. According to an EPA estimate, controlling the problem in the Great Lakes would cost from $8 to $13 billion, depending on the solutions selected. The regional administrator's view was that the large investment might impair the long-term funding ability of many local governments.

Whether EPA will provide funds is problematical. EPA's national water program is oriented to meeting municipal waste water treatment plant needs. EPA studies indicated that the combined sewer problem ranked fourth or fifth among national pollution problems.

In April 1973 the Administrator of EPA region V advised us that he anticipated the funding of selected projects to control combined sewer overflows in the major metropolitan areas of the Great Lakes in the immediate future. He stated that the effectiveness of the most highly sophisticated municipal and industrial waste water treatment plants would be significantly reduced without adequate combined sewer controls in these areas.

Developing technology for removing nutrients

Every lake goes through an aging process. However, this process has been greatly accelerated in the Great Lakes because of excessive amounts of nutrients, especially phosphorus and nitrogen. An oversupply of nutrients causes excessive growth of aquatic plants and organisms. These, in turn, deplete the oxygen supply needed in deep water to sustain fish and other aquatic life, produce undesirable taste and odors in water, and litter shorelines with rotting and foul-smelling aquatic plants.

During fiscal years 1965-72, EPA initiated 12 projects in the Great Lakes Basin to deal with removing nutrients. The total cost of the projects was $2.1 million.

Phosphorus removal

Seven of the eight Great Lakes States have adopted water quality standards which require removal of at least 80 percent of the States' phosphorus input--primarily from their municipal waste water discharges. Of the 12 nutrient removal projects initiated in the Great Lakes Basin during fiscal years 1965-72, 9 pertained to phosphorus removal. They cost $1.7 million.

Five projects, that we reviewed, costing $1.1 million, demonstrated that at least 60 percent of the phosphorus in municipal waste water discharges could be removed by adding chemicals, such as lime, iron, or aluminum. The projects were logical and comprehensive. They involved a progressive scale of demonstration, starting with a pilot project in 1966 and ending with a full-scale demonstration in 1970. They also involved different localities--Indiana, Michigan, Ohio, and Wisconsin--and different types of municipal treatment plants--primary, secondary, and advanced.

Although technology has been developed for removing phosphorus, relatively few municipalities in the Great Lakes Basin have installed facilities that meet the 80-percent removal requirement. For example, in the Great Lakes Basin area of EPA region V, which includes Illinois, Indiana, Minnesota, Michigan, Ohio, and Wisconsin, only 28 of the 324 municipalities that will have to meet the requirement had, as of April 1973, installed technology that removes 80 percent of the phosphorus.

Many of the municipalities received EPA construction grants for phosphorus removal and were constructing facilities and applying for grants to carry out the plans but had not submitted applications to EPA because funds were not available.

EPA region V was not authorized by EPA headquarters to release fiscal year 1973 construction grant funds until May 1973--1 month before the end of the fiscal year. Release of funds had been suspended by EPA headquarters pending development of guidelines to reflect requirements of the Federal Water Pollution Control Act Amendments of 1972. The region began releasing the funds authorized --about $500 million--in May 1973.

Nitrogen removal

Of the 12 nutrient removal projects initiated in the Great Lakes Basin during fiscal years 1965-72, 3 were for developing techniques for removing nitrogen. They cost about $400,000.

Research for nitrogen was limited because priority was given to phosphorus removal, which is more controllable. For example, some of the nitrogen in the lakes comes from the atmosphere, whereas the major source of phosphorus is municipal waste water discharges. Further, phosphorus removal technology was needed to meet State requirements of 80-percent removal, whereas standards for nitrogen removal had not been established.

According to an EPA region V official, only limited technology for removing nitrogen was available, and the cost was about twice that of removing phosphorus. In view of this, R&D to reduce the cost of removing nitrogen may have to increase.

Developing better methods for disposing of sludge

Sludge, residue remaining in a treatment plant after waste water is treated, contains a concentrated form of the objectionable pollutants removed in the treatment process. The volume of sludge is relatively small--usually 2 to 3 percent--in relation to the waste water volume treated. But handling and disposal is complex and troublesome and represents 25 to 50 percent of the capital and operating costs of a waste water treatment plant. Moreover, the problem will continue to grow as more advanced and effective waste water treatment processes are installed.

Since dumping sludge into the Great Lakes is prohibited, only two means of disposal are available to Great Lakes cities: incineration and land disposal. According to EPA, large cities in the region have had serious problems with both alternatives because:

--Incineration pollutes the air.

--Land disposal sites are usually some distance from the waste treatment facility, resulting in transportation costs. Also, land disposal meets with strong resistance from local landowners.

For fiscal years 1966-73, EPA spent nationally $8.2 million on sludge handling and disposal R&D. During fiscal years 1965-72, EPA obligated $2.2 million for four demonstration projects for sludge handling and disposal in the Great Lakes Basin.

Two of the projects pertained to techniques for land disposal of sludge. For the other two projects, EPA:

--Awarded a $261,000 grant to the Sewerage Commission of the City of Milwaukee in April 1968 to develop a system for dewatering sludge to reduce its volume by a slow freezing process.

--Awarded a $337,000 grant to the Lake County, Ohio, Department of Sanitary Engineering in January 1969 to evaluate a heat treatment process for reducing sludge volume.

Under the Milwaukee project, the commission determined, after spending about $40,000 of the authorized funds, that the slow freezing system was technically but not economically feasible. With EPA approval, the commission redirected the project to a small-scale study of a different procedure for processing sludge through municipal treatment plant filters. The study indicated that the procedure would reduce the volume of sludge. As a result, EPA in fiscal year 1973 awarded the sewage commission a grant for a full-scale evaluation of that technique. The evaluation was in progress as of November 1973.

The Lake County project was in progress as of November 1973. According to the project operator, the heat process involved had been used in Europe for about 10 years. He stated that the process, if proven more economical than present processes in the United States, would have good potential for widespread application.

The Administrator of EPA region V told us that sludge handling and disposal continues to be a serious problem in the Great Lakes region and that the improved waste water treatment plants constructed and being constructed will produce even greater quantities of solids and sludge. The research requirements statements he submitted to EPA headquarters for fiscal year 1974 indicated that additional research is necessary to:

--Develop guidelines for determining the most suitable means of sludge disposal for large cities.

--Demostrate to small cities the feasibility of disposing of sludge as an agricultural soil conditioner on nearby farm lands.

- Develop guidelines for land disposal of sludge, to minimize or prevent health hazards, odors, and pollution of ground and surface waters, soil, and plants.

Need for further development of technology to control water pollution from industrial sources

Industrial wastes are a significant source of water pollution in the Great Lakes Basin. The basin contains almost 50 percent of the Nation's steel-manufacturing capacity and high proportions of the Nation's capacity for refining petroleum and manufacturing chemical, paper, and food products.

In 1966, amendments to the Federal Water Pollution Control Act authorized Federal grants specifically for projects to develop new or improved methods of treating industrial wastes or otherwise preventing industrial pollution of waters. The amendments specified that such new or improved methods were to have industrywide application.

The Federal Water Pollution Control Act Amendments of 1972 call for substantially reducing water pollution from industrial sources and require:

- By July 1, 1977, application of the best practicable control technology currently available.

- By July 1, 1983, application of the best available technology economically achievable.

The amendments specify that applying the best available technology should help to achieve the national goal of eliminating the discharge of all pollutants into navigable waters by 1985.

Our review of EPA efforts as they have affected industries that contribute significantly to water pollution in the Great Lakes showed that:

- Technology that achieves the zero discharge goal has been developed for one industry (sugar beet processing), but its economic feasibility is questionable.

--Improved technology has been demonstrated for several industries, and the technology has been widely applied in at least two Great Lakes States.

--In general, however, further efforts are needed if Great Lakes industries are to substantially reduce pollution.

Development and demonstration efforts relating to Great Lakes industries

The types of industries that contribute significantly to water pollution in the Great Lakes, as identified through questionnaires we received from seven of the eight Great Lakes States, are:

Type of industry	States involved
Carbon and alloy steel	Illinois, indiana, Michigan, New York, Ohio, Pennsylvania
Pulp mills using the Kraft process	Michigan, Ohio, Pennsylvania, Wisconsin
Petrochemical	Michigan, Ohio, Pennsylvania
Food processing:	
Fruit	Michigan
Vegetables	Illinois
Sugar beets	Michigan
Soybeans	Illinois
Meat	Illinois

As part of its Applied Science and Technology program, EPA, during fiscal years 1969-72, spent about $16.5 million on R&D relating to these types of industries. The following table shows the breakdown of expenditures during fiscal years 1969-72.

Program element	Expenditures Nationwide (note a)	 Great Lakes Basin
	(millions)	
Metal and metal products (includes the carbon and alloy steel industry)	$ 2.1	$0.4
Paper and allied products (includes pulp mills using the Kraft process)	4.0	1.1
Chemical and allied products (includes the petrochemical industry)	4.8	.6
Food and kindred products (includes all food-processing industries)	5.6	1.0
Total	$16.5	$3.1

[a] Includes expenditures in the Great Lakes Basin.

EPA technology development programs are national rather than regional. The rationale is that technology can be developed for a particular industry at any location and applied to all firms in that industry. The Great Lakes industrial research needs are therefore addressed through the nationwide program as well as through projects in the basin.

Results achieved

What results have been achieved in controlling pollution from industries that contribute significantly to water pollution in the Great Lakes? In response to our request, EPA officials identified projects which, in their opinion, demonstrated or, when completed, will demonstrate significant technological advances that could have industrywide application. Eleven of the projects related to industries that are major contributors to Great Lakes pollution.

Industry	Projects EPA considers successful
Carbon and alloy steel	2
Pulp mills using the Kraft process	4
Petrochemicals	3
Food processing:	
Fruit and vegetables	1
Sugar beets	1
Soybeans	-
Meat	-
Total	11

The most successful of the 11 projects, according to EPA, involved the demonstration of a closed cycle (or closed loop) system that would provide zero discharge of pollutants in the sugar beet processing industry. That industry is a major contributor to water pollution in Michigan. Although EPA considers the project a significant success, a Michigan official told us that plants in Michigan had not applied the technology because they were small and old and they preferred to go out of business rather than install the technology.

EPA also told us that another of these projects demonstrated a dry caustic peeling process for the potato-processing industry that may be applicable to the fruit and vegetable processing industries, which are major pollutors in Michigan and Illinois. EPA said the process eliminates the need for water.

Of the remaining nine projects, five were full-scale demonstrations that had been completed. Two related to the carbon and alloy steel industry, two related to pulp mills using the Kraft process, and one related to the petrochemical industry.

State agencies' answering our questionnaires said that:

--A majority of the steel industries in Ohio were using technology demonstrated under one of the carbon and alloy steel projects.

- --A majority of the pulp industries in Wisconsin and some of the pulp industries in Michigan were using technology demonstrated under one of the pulp mill projects; some of the pulp industries in Ohio were using technology developed under the other pulp mill project.

The responses regarding the carbon and alloy steel and petrochemical projects were inconclusive. Some States told us they were unaware of the projects or did not know the extent of application. One of our consultants reviewed the petrochemical project which was completed in December 1971. In the consultant's opinion, the project was well-directed, involved a technology no other agency had investigated, and demonstrated technology that was both technically and economically feasible.

The responses of most of the Great Lakes States answering our questionnaire indicated that further efforts are needed to develop technology for industries on the Great Lakes to achieve the water pollution control goals of the Federal Water Pollution Control Act Amendments of 1972. An Office of Research and Development representative in EPA region V told us that, in his view, more emphasis should be placed on developing technology to control industrial water pollution.

CHAPTER 5

NEED TO IMPROVE COORDINATION OF WATER POLLUTION R&D ACTIVITIES

Aware of the many organizations involved in pollution-related research, the Congress has stressed the importance of coordination and has placed responsibility for such coordination on EPA. Since 1956, the Federal Water Pollution Control Act has required EPA (or its predecessors), in cooperation with Federal, State, and local agencies, to promote the coordination of research related to the causes, control, and prevention of water pollution.

Although EPA has primary responsibility for water pollution research on the Great Lakes, it did not, until 1972, have a research program specifically for the Great Lakes, and it relied on other organizations that lacked sufficient authority to promote research coordination.

EPA has recognized the need for better coordination, but has not exercised the leadership and initiative necessary to achieve it. As a result, Federal research has not produced as much knowledge about the Great Lakes' pollution problem as it could have.

MANY AGENCIES, MUCH INFORMATION

EPA's water quality research constitutes only part of the total Federal water research in the Great Lakes Basin. Seven other Federal agencies--each pursuing its own mission--also do, directly or indirectly, research related to water pollution. Their research includes collecting scientific data on the movement and composition of the water; the physical, chemical, and biological conditions in the water; and the effects of pollutants on fish and other aquatic life. Their estimated expenditures for water research in the Great Lakes during fiscal year 1972 follow.

Agency	Expenditures (millions)
Department of Commerce	$ 5.4
Department of Defense	2.0
Department of the Interior	.6
Department of Transportation	.3
AEC	.8
NSF	.8
NASA	.7
	$10.6

Much important water pollution information has been and is being developed through these agencies' research. Some of their more significant activities are summarized below and a more detailed discussion is included in appendix IV.

Department of Commerce

The Department of Commerce spent the largest amount on Federal water research effort in the Great Lakes Basin--$5.4 million in fiscal year 1972. Its efforts are centered in the National Oceanic and Atmospheric Administration--an agency established in 1970 to present a unified approach to environmental problems, including examining the sources of pollutants and their transport and dispersion within the environment.

The Administration carries out its research on the Great Lakes primarily through the National Sea Grant Program and the Lake Survey Center. (The Administration is also lead agency under IFYGL, which is discussed on pp.   and   .)

Department of Defense

The Corps of Engineers does most of the Department of Defense's research on the Great Lakes. The Corps spent $2 million during fiscal year 1972 to study alternative waste water management programs for Chicago, Cleveland, and Detroit. The Corps' future Great Lakes involvement is insured by the requirements of the 1972 amendments to the Federal Water Pollution Control Act. Under the act, the Corps must make a specific $5 million study of waste water management on Lake Erie.

Department of the Interior

The Department of the Interior carries out its water research in the Great Lakes Basin principally through the Bureau of Sport Fisheries and Wildlife (BSF&W), the Geological Survey, and the Office of Water Resources Research.

BSF&W is concerned with protecting and enhancing the habitat of fish and wildlife and in assisting States in fisheries management. During fiscal year 1972, BSF&W's laboratory in Ann Arbor spent about $302,000 on research to assess the effects of heat, pesticides, and heavy metals on fish.

As shown below, the agencies had common research concerns. Moreover, they performed or supported research in areas where EPA indicated a need for data.

Research Areas of General Concern
Among Federal Agencies in the Great Lakes (note a)

	Agencies							
		Commerce		Defense	The Interior			
Research areas	EPA	Sea Grant Program	Lake Survey Center	Corps	BSF&W	Geological Survey	Office of Water Resources Research	AEC
Pollution effects on aquatic life	X	X		X	X		X	
Water characteristics	X		X			X		
Movement of pollutants	X	X		X		X	X	X
Mathematical modeling	X	X	X			X	X	
Remote sensing	X					X		
Pesticides and other toxic substances	X	X			X			
Thermal pollution	X	X			X			X
Alternative waste treatment methods	X	X		X				

[a] Does not include agency efforts under the IFYGL program, which includes research in all but the last area.

NEED FOR COORDINATION RECOGNIZED

A May 1971 EPA assessment document on research programs for the Great Lakes summed up the lack of coordination as follows.

> "There is a large and diverse amount of Great Lakes research underway. These present Great Lakes research programs, conducted by anyone, anywhere, must be sorted, evaluated, and placed in the framework of EPA's mission and needs. It is EPA's responsibility to identify the research necessary to meet its Great Lakes environmental obligations (standards and enforcement), identify the centers of scientific and engineering talent for doing it, and to exercise the leadership and initiative to see that [it] is done." (Underscoring supplied.)

Further, the Director of EPA's Grosse Ile Laboratory stated in April 1972, that:

> "While there is some informal exchange of research proposals, there is no overall coordinated research effort for the Great Lakes. The various agencies appear to be governed by the missions of the agencies, with coordination of the research program being of secondary interest." (Underscoring supplied.)

A March 1973 draft report[1] on the IFYGL program characterized past research efforts as "a piece-meal, free-for-all approach to the Great Lakes."

Officials of other agencies and universities labeled EPA's efforts to coordinate research inadequate. According to the Assistant Director of the BSF&W laboratory in Ann Arbor, there is little or no coordination of agencies' research programs to achieve common objectives. Officials from the Grant Programs at the Universities of Michigan and Wisconsin also pointed out the need to improve coordination.

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[1] Issued by the U.S. National Committee for the International Hydrological Decade, Division of Earth Sciences, National Research Council.

As discussed in chapter 3, EPA still has to acquire much more detailed knowledge about Great Lakes pollutants--their sources, quantity, dispersion, fate, and effects. It needs this knowledge to adequately set and enforce sound water quality standards and to predict the effect on water quality of proposed and applied technical methods of abatement.

Failure to use other Federal agencies' pollution-related research efforts therefore delays EPA in acquiring the knowledge it must have.

FACTORS IMPAIRING EFFECTIVE COORDINATION

Two factors have impaired EPA's effectiveness in promoting coordination of pollution-related water research on the Great Lakes.

Lack of a Great Lakes research program

EPA research on the Great Lakes from 1968 to 1972 was sporadic and piecemeal because it was not done in accordance with a comprehensive Great Lakes research program. Without an effective research program, EPA lacked a framework for coordinating with other agencies.

Reliance on other organizations to coordinate research

To coordinate its water research efforts with other Federal agencies, EPA has relied on its participation in the Great Lakes Basin Commission and the International Great Lakes Study Group--organizations that do not have enough authority to effectively promote coordination.

The Great Lakes Basin Commission--established in 1967 under the Water Resources Planning Act of 1965 (42 U.S.C. 1962)--includes representatives of various Federal agencies and the eight States surrounding the Great Lakes. It is the principal agency for coordinating Federal, State, interstate, local, and nongovernmental water resources planning in the basin--a much broader matter than water pollution research. Under its charter, the Commission has only an implied responsibility for coordinating Federal water research efforts in the Great Lakes Basin. The Commission's Executive Director said it has no authority to direct agency efforts or to require implementation of research programs. As a result, it can only use its influence and persuasion to coordinate research, and its efforts have not been fully effective.

The International Great Lakes Study Group, formed in 1962, is an informal organization composed of representatives of agencies and institutions in Canada and the United States engaged in research on Great Lakes waters. Although the study group provides a good forum for exchanging general program information, it does not have the authority to coordinate research.

More recently, in December 1972, EPA took the lead in organizing a conference of Federal program managers for Great Lakes research. The conference was sponsored by the Interagency Committee on Marine Science and Engineering of the Federal Council for Science and Technology, to have each agency present details on its research program and plans for the Great Lakes; the overall objective was to assess the strengths and inadequacies of the programs and to increase coordination among agencies. The published results of the conference were not available as of June 1973. However, the Director of the Gross Ile Laboratory told us he believes some benefits will be derived from the conference.

ACTIONS TO COORDINATE RESEARCH ON THERMAL POLLUTION

Thermal pollution, which results from the discharge of heated waste water, could be a problem of increasing significance on Lake Michigan because the lake is a favored location for actual or proposed nuclear power plants--a major source of heated water discharges.

EPA, BSF&W, and AEC have been doing thermal pollution research on the Great Lakes since 1969. EPA and BSF&W have mostly done laboratory research, while AEC has supported field research on Lake Michigan done by the Argonne National Laboratory.

EPA and BSF&W arrived at a different opinion than AEC as to the effects thermal discharges have on the Great Lakes ecology. For example, at the third session of the Lake Michigan Enforcement Conference in 1970:

--BSF&W reported that the effects of waste heat could be a detrimental environmental influence.

--An Argonne National Laboratory official reported that it was possible that discharging heated water into Lake Michigan was an appropriate and acceptable use of a natural resource.

A technical committee appointed by the Lake Michigan conferees commented on thermal pollution research in a 1969 report as follows.

> "Various power companies and consultants and Federal and State agencies presently are making more or less independent investigations. All of these investigations should be coordinated to the maximum extent possible."

Recent developments should improve coordination of thermal research. The Federal Water Pollution Control Act Amendments of 1972 require EPA, in cooperation with Federal, State, public, and private organizations, to continually study the effects and methods of controlling thermal discharges.

In December 1972 EPA region V established a committee to assess the damage to Lake Michigan's ecology that could occur from heated discharges. The committee includes representatives of EPA, the Argonne National Laboratory, BSF&W, universities, and industries. The committee designated subcommittees to deal with specific problems, such as the effects of heat on aquatic life and the physical, chemical, and radioecology aspects of thermal discharges. The assessment was continuing as of August 1973.

In October 1973, AEC officials told us that:

> "* * * AEC has, through its Lake Michigan thermal research program with ANL [Argonne National Laboratory], endeavored to have both EPA and BSF&W participate jointly with the ANL staff in carrying out field thermal studies below certain power plants on Lake Michigan in order to resolve conflicting opinions about the effects of thermal discharges. To date, neither of these agencies has been interested in participating in this type of field research."

CHAPTER 6

INTERNATIONAL ASPECTS OF RESEARCH

The United States and Canada are jointly concerned about the Great Lakes' water pollution problems. Both have contributed to the problems, and both have tried to remedy them. But, before 1972, the two countries had not provided for regular, continuing coordination of their antipollution efforts, including research. Consequently, they did not obtain all the knowledge they could have.

To remedy the situation, the United States and Canada entered into the Great Lakes Water Quality Agreement of 1972, which made the International Joint Commission (IJC) responsible for helping to coordinate and evaluate all Great Lakes antipollution measures. Regarding research, IJC is to identify objectives, advise the Governments, and disseminate research information. It is assisted by the Research Advisory Board. (See p. 53.)

INTERNATIONAL COOPERATION IN WATER RESEARCH BEFORE 1972

Before the agreement of 1972, the United States and Canada occasionally coordinated their research activities on the lakes. For example, in 1966 the United States and Canadian scientific communities initiated a major joint program--IFYGL--as a contribution to the International Hydrological Decade (1965-74), which functions under the auspices of the United Nations Educational, Scientific, and Cultural Organization. IFYGL is focusing on one lake--Ontario--to develop an efficient, economical method of collecting data to help solve problems in the Great Lakes.

The program, to be completed in 1977, will cost about $35 million. Seven Federal agencies as well as Canadian agencies are funding the effort. U.S. agencies will fund about $24 million of the program's cost, as shown below.

Estimated Total IFYGL Program Cost
Fiscal Years 1970-77

Federal agencies	Total funding as of fiscal year	
	1972	1977
	(000 omitted)	
Department of Commerce	$ 4,149	$17,636
Department of Defense	740	1,140
Department of the Interior	140	270
Department of Transportation	295	607
EPA	785	2,700
NASA	500	1,000
	460	1,030
Total--United States	$ 7,069	$24,383
Total--Canada	3,550	10,800
Total	$10,619	$35,183

The basic United States-Canadian agreement on the Great Lakes is covered in the Boundary Waters Treaty approved by the Senate in 1909. The treaty was aimed at preventing and settling disputes over the use of boundary waters, including but not limited to the Great Lakes, and provided that boundary waters and waters flowing across the boundary were not to be polluted on either side to the point of injuring health or property of the other.

To carry out its purposes, the treaty established IJC, a permanent body made up of three members from the United States and three from Canada. But it gave IJC only limited responsibilities in the matter of pollution and limited it to investigating and making recommendations on problems referred to it by either Government.

In response to requests by the Governments, IJC made three major pollution studies on Great Lakes waters between 1909 and 1970. A brief summary follows.

--In the period 1912-18, IJC made a study and found that in certain areas of the lakes, pollution endangered the welfare of citizens in both countries. Moreover, IJC recommended that it be given the authority to regulate and prohibit such pollution. The two Governments, however, did not adopt this recommendation.

--From 1946 to 1950 IJC examined pollution problems in connecting channels of the Great Lakes. As a result, it recommended adopting specific water quality objectives. The two Governments approved the objectives, which were subsequently a part of the pollution abatement programs of enforcement agencies in both countries.

--Finally, from 1964 to 1970, IJC made a study of water pollution in lakes Erie and Ontario and in the international section of the St. Lawrence River. According to an IJC report, it was the most extensive water pollution study undertaken anywhere up to that time. It involved the use of studies made by other agencies and the participation of 12 United States and Canadian agencies and several hundred scientific and technical experts.

On the basis of the last study, IJC recommended that common water quality objectives be established for Great Lakes waters and that the United States and Canada enter into an agreement on programs and measures, including research, to achieve the objectives. IJC further recommended that its powers be expanded to include coordinating and monitoring efforts to implement any international agreements reached. These recommendations led directly to the agreement discussed below.

THE GREAT LAKES WATER QUALITY AGREEMENT OF 1972

The Great Lakes Water Quality Agreement of 1972 was a major United States-Canadian action to address the pollution problems of the lakes. It was intended to provide a basis for more effective cooperation to restore and enhance the lakes' water quality. The agreement:

--Established general and specific water quality objectives for the lakes.

--Designated programs and other measures to achieve the objectives. It specified that such programs and measures be completed or in process by December 31, 1975.

--Assigned to IJC responsibilities and functions for implementing the agreement.

IJC's responsibilities include helping to coordinate Great Lakes water quality research by:

--Identifying research objectives.

--Giving advice and recommendations concerning research to the National, State, and Provincial Governments.

--Disseminating research information to interested persons and agencies.

In addition, the agreement provided for IJC to inquire into and report on

--pollution of Great Lakes waters from agriculture, forestry, and other land use activities, and

--actions needed to preserve and enhance the quality of the waters of Lakes Huron and Superior.

Research Advisory Board

To help with its research responsibilities, IJC established the Research Advisory Board, composed of 16 members--8 from each country. The initial appointments, in November 1972, included people from National, State, and Provincial governmental agencies; the academic, scientific, and industrial communities; and the public. Two members are EPA's Assistant Administrator for Research and Development and the U.S. Director, IFYGL, National Oceanic and Atmospheric Administration.

The Board's main function is to review Great Lakes research activities at regular intervals and to:

--Examine the adequacy and reliability of research results, their dissemination, and the effectiveness of their application.

--Identify deficiencies in the scope, funding, and completion schedules of the research.

--Identify other research projects that should be undertaken.

--Identify specific research programs for which international cooperation will be productive.

In addition, the Board is to facilitate both formal and informal international cooperation and coordination of research.

In December 1972, the Board established seven standing committees to meet the need for specialists' advice on particular topics, such as waste water treatment and lake dynamics. The 45 members it appointed to these committees were affiliated with a variety of universities and governmental agencies. The Board also began to identify all current research activities on the Great Lakes as a basis for carrying out its reviews.

In October 1973, the Board submitted to the IJC a report on "Research Needs: Great Lakes Water Quality." The report identified 10 high-priority research needs. It described them as pertaining to water quality problems" * * * where information is absent, inadequate, or not easily accessible; thus creating an atmosphere in which it is difficult to make rational, well-informed, scientifically-based management decisions for the Great Lakes."

Most of the research needs cited in the report related to the same general area of need discussed in chapter 3--namely, research into the sources, fate, and effects of pollutants. They included, for example, research into the:

--Role of atmospheric inputs (rainfall, snowfall, and dustfall) as sources of pollution.

--Relationship between nutrient inputs (primarily phosphorus and nitrogen) and the stage of eutrophication of the lakes.

--Transport and dispersal of pollutants.

--Effects of heated waste water discharges (thermal pollution).

The report's explanations as to why such research is needed referred to the practical uses of detailed knowledge about the processes and effects of pollutants. For instance, regarding research into the effects of thermal pollution, the report stated that:

> "Presently available data and understanding are inadequate to definitively assess the degree of protection required, and the likely environmental and economic consequences of alternatives to direct discharge of waste heat to waters. Thus there is an urgent need for a better scientific basis on which to establish objectives and regulations." (Underscoring supplied.)

In general, we believe the Board's report reinforces the point discussed in chapter 3, that more detailed knowledge about the processes and effects of pollutants is necessary as a basis for determining what measures would effectively remedy Great Lakes pollution problems.

Factors affecting achievement of IJC goals

IJC's Board does not have its own research facilities. It must seek analyses, assessments, and recommendations from professional, academic, governmental, or intergovernmental groups.

IJC, moreover, is not assured that funds needed to accomplish its goals will be available. The agreement provides that obligations undertaken in the agreement be subject to the appropriation of funds by the two countries. The countries committed themselves "to seek" the appropriation of funds needed to develop and implement the programs spelled out in the agreement and the funds IJC needs to effectively carry out its responsibilities.

Finally, IJC cannot require corrective action. It must report annually to the two National Governments and the State and Provincial Governments on progress toward achieving the water quality objectives and the effectiveness of the programs and measures undertaken. It may at any time make special reports to them on any problem. The National Governments review the IJC reports and consider appropriate action, but IJC cannot force them to take such action.

Because of its dependency on others, IJC cannot insure a comprehensive and coordinated Great Lakes research effort. Therefore, if the U.S. contribution under the agreement is to be effective, Federal agencies' programs must be sound and the agencies must be willing and able to coordinate them. In our opinion, these factors reinforce the necessity for EPA, as the major Federal antipollution agency, to initiate and carry out a comprehensive Great Lakes processes and effects research program on the behalf of the United States and to exercise leadership in cooperation with IJC, in improving coordination of Federal water pollution research on the Great Lakes.

CHAPTER 7

CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

CONCLUSIONS

Through its R&D programs, EPA has helped combat pollution in the Great Lakes, improving its knowledge of water pollution and developing technology to control it. But, much remains to be done.

Certain factors have limited EPA's progress in meeting the lakes' R&D needs. EPA has not acquired enough detailed knowledge of the processes and effects of Great Lakes pollutants because it had not carried out a comprehensive research program specifically for Great Lakes waters. Instead, it has relied on its national research programs, which have only limited applicability to the lakes. Without detailed knowledge, EPA and State agencies do not have an adequate basis for setting and enforcing sound water quality standards and for predicting and evaluating how proposed and applied technical methods of abating pollution will affect water quality.

Recognizing its need for more effective research, EPA, in 1972, initiated two programs for the Great Lakes. Under its long-term program, it is participating with other Federal and Canadian agencies in certain research on the lakes. But, in fiscal year 1973, EPA substantially reduced the scope of its short-term program due to changes in priorities. This will mean further delay in acquiring the detailed knowledge needed to control the pollution most effectively.

Legislation enacted in 1965 and 1966 authorized EPA, under national programs, to develop and demonstrate technology to control Great Lakes pollution problems caused by municipal and industrial sources. In addition, 1970 legislation authorized EPA to carry out a specific program to demonstrate new methods and to develop preliminary plans for controlling Great Lakes pollution.

We found that:

--EPA has prepared a plan but has completed no demonstration projects under a specific Great Lakes program because of late program funding in fiscal year 1971, the time required to develop a plan in fiscal year 1972 to carry out the program, and funding limitations imposed by OMB in fiscal year 1973.

- --Technology has been developed that could alleviate two significant Great Lakes problems caused by municipal sources--combined sewer overflows and phosphorus discharges. However, relatively few Great Lakes cities have applied this technology because of its high cost and/or the lack of sufficient Federal construction grant funds for treatment plants. Research on two other problems--nitrogen discharges and disposal of treatment plant sludge--has not produced solutions and greater efforts are needed.

- --Control technology has been developed for various industries contributing significantly to Great Lakes pollution. But, more work is needed to substantially reduce industrial water pollution as called for by the Federal Water Pollution Control Act Amendments of 1972.

There has been little team effort among the various Federal agencies involved in pollution-related R&D on the Great Lakes. Since 1956, the Federal Water Pollution Control Act has required EPA and its predecessor agencies to promote coordination. However, it has not exercised the leadership and initiative to achieve it. As a result, Federal R&D has not provided as much knowledge about the Great Lakes as it could have.

The Great Lakes water pollution problems are international. Although both the United States and Canada are concerned about pollution, before 1972 they had not provided for regular, continuing coordination of their water pollution control work, including R&D. To remedy the situation, the two countries entered into the Great Lakes Water Quality Agreement of 1972. The agreement made IJC responsible for helping to coordinate and evaluate all Great Lakes antipollution measures. Regarding research, IJC is to identify objectives, advise the Governments, and disseminate research information. It is assisted by the Research Advisory Board composed of people from Government; the academic, scientific, and industrial communities; and the public.

We believe IJC, as an international coordinating organization, can help bring about a more comprehensive and coordinated

Great Lakes research effort. But, because IJC depends primarily on governmental organizations for such things as research facilities, funding, and enforcement action, it cannot, by itself, insure that such an objective is achieved.

If the U.S. contribution under the agreement is to be effective, Federal agencies' programs must be sound and the agencies must be willing and able to coordinate them. These factors underscore the need for EPA to initiate and carry out a comprehensive Great Lakes processes-and-effects research program and to exercise leadership, in cooperation with IJC, in improving coordination of Federal water pollution research on the Great Lakes.

RECOMMENDATIONS

We recommend that the Administrator, EPA

--initiate and carry out a comprehensive Great Lakes processes-and-effects research program aimed at determining the sources, quantity, dispersion, fate, and effects of pollutants, and

--exercise leadership, in cooperation with IJC, in improving the coordination of Federal water pollution research on the Great Lakes.

Because EPA's R&D programs for solving municipal and industrial water pollution problems are carried out nationwide, our recommendations on those programs, which would also help solve these problems with respect to the Great Lakes, are stated in volume I of this report.

AGENCY COMMENTS

In September 1973 matters discussed in this report were presented to EPA, the Great Lakes Basin Commission, and IJC. These agencies generally agreed with our findings. Their comments are contained in volume I, app. II. EPA stated that it is doing its best to provide leadership to a coordinated Great Lakes water production research effort but that it did not have the resources and/or authority to adequately coordinate Federal research on the Great Lakes.

PRINCIPAL AGENCIES AND OFFICIALS

CONTACTED DURING OUR REVIEW

FEDERAL AGENCIES AND OFFICIALS

EPA:		
Mr. Valdas V. Adamkus	Deputy Administrator, region V	Chicago, Ill.
Dr. John L. Buckley	Deputy Director, Office of Research	Washington, D.C.
Mr. Ralph G. Christensen	Program Coordinator for Demonstration Projects on the Great Lakes, region V	Chicago, Ill.
Dr. Tudor T. Davies	Laboratory Director	Grosse Ile, Mich.
Mr. Arnold B. Joseph	Acting Chief, Office of Research, Transport Process Branch	Washington, D.C.
Mr. Francis T. Mayo	Administrator, region V	Chicago, Ill.
Dr. Donald I. Mount	Director, National Water Quality Laboratory	Duluth, Minn.
Mr. Carlysle Pemberton, Jr.	Great Lakes Coordinator, region V	Chicago, Ill.
Mr. Clifford J. Risley, Jr.	Director, Office of Research and Development, region V	Chicago, Ill.
Dr. David G. Stephan	Director of Program Management	Washington, D.C.
Mr. John I. Teasley	Assistant to the Director, National Water Quality Laboratory	Duluth, Minn.
Mr. Nelson Thomas	Deputy Director, Laboratory	Grosse Ile, Mich.
CORPS OF ENGINEERS:		
Mr. Robert L. Gregory	Chief, Basin Planning Section	Detroit, Mich.
Mr. D. J. Leonard	Hydrologist	Chicago, Ill.
Mr. Philip McAllister	Civilian Engineer	Detroit, Mich.
Mr. Barry Pritchard	Resident Engineer	Cleveland, Ohio
Col. Myron D. Snoke	District Engineer	Detroit, Mich.
Mr. E. J. Weiss	Chief, Planning Division	Chicago, Ill.
NASA:		
Dr. Herman Mark	Assistant Chief, Aerospace Environment Branch, Lewis Research Center	Cleveland, Ohio
Dr. Louis Rosenblum	Chief, Direct Energy Conversion Division, Lewis Research Center	Cleveland, Ohio
BSF&W:		
Mr. John F. Carr	Assistant Director, Great Lakes Fishery Laboratory	Ann Arbor, Mich.
Dr. Howard Tait	Director, Great Lakes Fishery Laboratory	Ann Arbor, Mich.

FEDERAL AGENCIES AND OFFICIALS (continued)

AEC:		
Mr. E. D. Croke	Director, Center for Environmental Studies, Argonne National Laboratory	Chicago, Ill.
Mr. P. F. Gustafson	Associate Director, Radiological and Environmental Research Division, Argonne National Laboratory	Chicago, Ill.
Mr. Barton M. Hoglund	Assistant Director, Center for Environmental Studies, Argonne National Laboratory	Chicago, Ill.
GEOLOGICAL SURVEY:		
Mr. T. Ray Cummings	District Chief, Michigan District	Lansing, Mich.
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION:		
Dr. Eugene J. Aubert	Director, IFYGL Project Office	Rockville, Md.
Dr. Leo Bajorunas	Director. Limnology Division, Lake Survey Center	Detroit, Mich.

STATE AND LOCAL AGENCIES AND OFFICIALS

CLEVELAND WATER QUALITY PROGRAM DEPARTMENT OF PUBLIC UTILITIES:		
Mr. Dennis S. Case	Project Director	Cleveland, Ohio
MICHIGAN WATER RESOURCES COMMISSION:		
Mr. Richard Emerson	Chief, Water Quality Management Planning Section	Lansing, Mich.
Mr. Carlos M. Fetterolf	Chief Environmental Scientist	Lansing, Mich.
Mr. Francis B. Frost	Chief Engineer	Lansing, Mich.
Mr. William D. Marks	Chief, Water Development Services Division	Lansing, Mich.

CANADIAN AGENCIES AND OFFICIALS

CANADA CENTER FOR INLAND WATERS:		
Mr. James P. Bruce	Director	Burlington, Ontario
Mr. John MacDowall	IFYGL Coordinator	Burlington, Ontario
ONTARIO MINISTRY OF ENVIRONMENT:		
Mr. A. J. Harris	Director, Research Branch	Toronto, Ontario
Mr. Frederick A. Voege	Executive Director, Laboratory and Research Division	Toronto, Ontario

OTHER ORGANIZATIONS AND OFFICIALS

DETROIT EDISON COMPANY:		
Mr. J. F. DeLange	Director, Environmental Research Division	Detroit, Mich.
Dr. Harold Meyer	Chief, Water Pollution Research	Detroit, Mich.
GREAT LAKES BASIN COMMISSION:		
Mr. Leonard T. Crook	Executive Director	Ann Arbor, Mich.
Mr. Frederick O. Rouse	Chairman	Ann Arbor, Mich.
UNIVERSITY OF MICHIGAN:		
Dr. John M. Armstrong	Director, Michigan Sea Grant Program	Ann Arbor, Mich.
Dr. David C. Chandler	Director, Great Lakes Research Division	Ann Arbor, Mich.
UNIVERSITY OF WISCONSIN:		
Dr. Theodore Green III	Associate Professor of Meteorology, Marine Studies Center	Madison, Wis.
Dr. Clifford H. Mortimer	Director, Center for Great Lakes Studies	Milwaukee, Wis.
Dr. Robert A. Ragotzkie	Director, Wisconsin Sea Grant Program	Madison, Wis.

EPA PROJECTS VISITED

DURING OUR REVIEW

Development of a system for conditioning and dewatering sludge by freezing	Milwaukee, Wis.
Phosphorus removal with pickle liquor in an activated sludge plant	Milwaukee, Wis.
Water pollution abatement program--removal of phosphorus with pickle liquor	Mentor, Ohio
Demonstration of a process for heat treatment of sludge	Painesville, Ohio
Waste water flow measurement in sewers using ultrasound	Milwaukee, Wis.
Design, construction, operation, and evaluation of a demonstration waste treatment device--the rotating biological contactor	Milwaukee, Wis.
Overflow detention and chlorination facility	Milwaukee, Wis.
Demonstration of screening dissolved air flotation treatment as an alternative to combined sewer separation	Racine, Wis.
Sewer system monitoring and remote control	Detroit, Mich.
Screening flotation treatment of combined sewer overflow	Milwaukee, Wis.
Demonstration of an underground storage-treatment facility for excess combined sewage	Akron, Ohio
Demonstration of combined sewer overflow control techniques for water quality improvement and beach protection	Cleveland, Ohio

Construction of a facility to demonstrate offshore underwater temporary storage of storm overflow from a combined sewer	Sandusky, Ohio
Underwater temporary storage of storm overflow from a combined sewer	Sandusky, Ohio
Large-scale demonstration of treatment of storm-caused overflow by the screening method	Fort Wayne, Ind.
Advanced waste treatment using physical chemical process	Painesville, Ohio
Demonstration of phosphate removal and other waste water treatment techniques	Fort Wayne, Ind.
Sewage phosphorus removal by an activated sludge plant	Milwaukee, Wis.
Development of phosphate removal process	Detroit, Mich.
Electroplating waste treatment and water reuse	Wauwatosa, Wis.

EXTENT OF GREAT LAKES POLLUTION (note a)

LAKE ERIE

The Great Lakes' most populous and most polluted basin is Lake Erie. Some 11 million people live in the area. It includes two of America's major cities--Detroit and Cleveland--and other populous areas--Toledo, Sandusky, Lorain-Elyria, Akron, and Ashtabula in Ohio and Erie, Pennsylvania. Buffalo, which sits at the eastern end of the lake, discharges effluents into the Niagara River and is thus only a minor factor in polluting Lake Erie.

There is a vast concentration of chemical, steel, mineral, transportation, and manufacturing industries on Lake Erie. Major industrial areas are Detroit-Ann Arbor-Monroe, Michigan; Cleveland-Lorain-Elyria-Akron, Sandusky, and Ashtabula; and Erie. Further, the Maumee River drainage system, the largest agricultural area in the Great Lakes Basin, feeds into Lake Erie.

The effects of pollution from the above sources are extreme: oxygen levels in areas of the lake bottom are reduced to zero, and many indigenous fish populations are displaced by scavenger and trash fish. Discharge of untreated sewage from combined sewers has compelled the closing of most beaches on the lake. The area of lake bottom where regeneration takes place--the zone of zero oxygen--is spreading.

LAKE ONTARIO

Approximately 3 million people live in the Lake Ontario watershed. Larger cities include the Buffalo-Niagra Falls area, Rochester, Oswego, Syracuse, and Watertown, New York.

Basin industries are diversified. Concentrated primarily in the Buffalo-Niagra Falls and Rochester areas are steel, transportation, metalworking, oil, and chemical industries. Major pulp and paper industries are scattered, with concentrations in Oswego and along the Black River.

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[a] Sources: EPA document "Accelerated Great Lakes Program" prepared in late 1971.

Flow entering Lake Ontario from the Niagra River is the single largest source of pollution on the lake because the river is polluted at its source, Lake Erie, and receives more pollution from municipal and industrial sources along its 30-mile course. Significant contributions are made in the Hamilton-Toronto and Ontario areas. Other major U.S. sources are the Rochester areas of the central lake and the Watertown-Black River areas near the eastern end of the lake.

These sources have made the situation on Lake Ontario the second worst in the Great Lakes Basin. Nutrient enrichment has caused a major threat of aging of the lake, fish populations have been damaged, and recreational values have been reduced. The problem is worse in near-shores areas nearest population concentrations but is most widespread in the western portion of the lake.

LAKE MICHIGAN

Approximately 6 million people live in the Lake Michigan Basin. Major cities include Green Bay, Maintowoc, Sheboygan, Milwaukee, Kenosha, and Racine, Wisconsin; Gary, Hammond, and South Bend, Indiana; and Kalamazoo, Muskegon, Grand Rapids, Lansing, and Manistee, Michigan. Although Chicago, with 3.5 million people and the busiest inland seaport in the world, sits at the southwest corner of the lake and depends on the lake for its water supply, most of its wastes are discharged into the Mississippi River system.

There is a vast industrial concentration in the basin. Industry uses more water from Lake Michigan than from the rest of the lakes. Principal industrial areas are Chicago-Gary-Hammond; Appleton-Green Bay, Wisconsin; and Milwaukee. Other major, but smaller, centers are in Manitowoc, Sheboygan, and Kenosha-Racine, Waukegan, Illinois; South Bend; and Muskegon, Benton Harbor-St. Joseph, Kalamazoo, Grand Rapids, Manistee, and Traverse City, Michigan.

Pollution from the above industrial sources, as well as from major municipal discharges, has severely affected near-shore areas along major parts of the Wisconsin, Illinois, and Indiana shores and large parts of the Michigan shoreline. Southern Lake Michigan and southern Green Bay are, perhaps, the worst polluted areas. Impact on recreation has been severe; beaches in Green Bay, Milwaukee, the Chicago North Shore, and the Hammond-Whiting area have been closed for as long as 30 years. The impact of pollution is also felt in open water areas of the southern part of the lake and in isolated harbor dredging spoils-dumping areas in open waters.

Lake Michigan is considered the third most threatened lake following Erie and Ontario and is threatened by industrial and municipal sources, storm and combined sewer discharges, agricultural runoff, urban sediment, and thermal discharges. The lake floor is divided into two basins and currents are slow and ill-defined. Thus, the flushing action present in all freshwater bodies is very slow in Lake Michigan, requiring some 100 years, compared to Lake Erie's 3 years. Any serious buildup of pollution in Lake Michigan will consequently be slow to reverse. Already, pesticide levels in fish are the highest in the Great Lakes. Incipient aging of the lake is of particular concern in those near-shore areas which are used a great deal, although also to some extent in the open waters of the southern part of the lake.

LAKE HURON

Some 1.2 million people live along the shores and tributaries of Lake Huron. Larger cities include Saginaw, Bay City, Midland, and Alpena, Michigan. Although the water quality is good lakewide, in local areas, particularly along the shoreline, bays, and tributaries, symptoms of premature aging are appearing.

Industries in the basin are concentrated in the Saginaw Bay area which has the most significant pollution problems. Discharges from the chemical complexes of Midland and Alma and the effluents of general industry and canning operations in Saginaw and Bay City combine with municipal inputs of bacteria and nutrients to promote algae growths and generally degrade water quality in the bay. Lesser damage occurs along the Au Sable River and along the lake shores near Alpena and Harbon Beach from municipal, chemical, and paper-manufacturing discharges.

LAKE SUPERIOR

Lake Superior is the largest, cleanest, and most undeveloped of the Great Lakes. About one-half million people live in its watershed. Larger cities include Duluth; Superior, Wisconsin; and Marquette, Michigan.

Industries in the basin are concentrated in the Cloquet-Duluth-Superior-St. Louis River area, although a mining company in Silver Bay is the lake's single largest potential polluter in quantitative terms, and other industries are scattered along the shores of Wisconsin and Michigan's Upper Peninsula. Paper, primary metal, steel, and chemical are the major industries in the basin.

Although most of the lake is unspoiled, some local degradation has occurred. The worst pollution is in the Duluth-Superior Harbor area where bacterial and nutrient components exist in addition to industrial effluents. Local recreation has been severely affected and two beaches have been closed. Primary scattered sources of pollution in the basin are paper and pulp mills, mining operations, municipal sources, steel mills, and chemical plants.

DESCRIPTION OF FEDERAL AGENCIES' WATER POLLUTION-RELATED RESEARCH PROGRAMS ON THE GREAT LAKES

AEC

AEC does most of its research on the Great Lakes under contract with the Argonne National Laboratory. AEC is mainly assessing the environmental impact of thermal discharges from nuclear power plants and making an ecology study to determine the radiological status of Lake Michigan.

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

The Administration is actively involved in water pollution research on the Great Lakes and has concentrated its efforts under the National Sea Grant Program and the Lake Survey Center of the National Ocean Survey.

The National Sea Grant Program is a university-centered research program. The University of Michigan, the University of Wisconsin, and the State University of New York/Cornell do most of the research, which involves studies of alternative methods of waste water treatment, the effects of toxic substances on aquatic organisms, and the environmental impact of cooling towers.

The Administration's water research under the Lake Survey Center is intended to determine the complex interrelationships of the lakes' natural processes. The research includes mathematical modeling of the natural lake processes, analyzing hydrologic factors affecting the Great Lakes, and studying the effects of various types of lake bottoms on water quality.

The Lake Survey Center research program on the Great Lakes began in 1962 while the center was a part of the Corps of Engineers. Its program was transferred to the Administration in October 1970 when the Administration was established as an agency.

The Administration was also designated as lead agency of the IFYGL program in 1971. This program involves an intensive field program to collect data on the physical, chemical, and biological characteristic of Lake Ontario. It is expected that the information developed will be applicable to solving problems in the other Great Lakes.

DEPARTMENT OF DEFENSE

Corps of Engineers

The Corps, under its broad national research program, has conducted some water quality research applicable to the Great Lakes. Specifically, its Great Lakes projects included

--a study of dredging operations in the Great Lakes undertaken in cooperation with FWPCA and the Department of the Interior and

--studies of alternatives for waste water treatment in Chicago, Cleveland, and Detroit.

The future role of the Corps in Great Lakes water pollution activities promises to expand. Under provisions of the 1972 amendments to the Federal Water Pollution Control Act, the Corps was authorized $5 million to design, develop, and demonstrate a waste water management program on Lake Erie.

DEPARTMENT OF THE INTERIOR

BSF&W

BSF&W does water pollution research mainly at the Great Lakes Fishery Laboratory in Ann Arbor to assess the effects of heat, pesticides, and heavy metals, such as lead and mercury, on fish. BSF&W also does research applicable to the Great Lakes at its laboratories in Columbia, Missouri; LaCrosse, Wisconsin; and Hammond Bay, Michigan.

Geological Survey

The Geological Survey, acting under its mandate to examine the geological structure, mineral resources, and products of the national domain, carries out a water resources research program in the Great Lakes Basin. The Survey's national research program also has applicability to the Great Lakes. Research on the Great Lakes includes research of ground water pollution, stream sediment, and lake evaporation; a study of Lake Ontario, using satellite surveillance; and studies of surface waters.

Office of Water Resources Research

The Office does not have a Great Lakes research program. However, it has funded research at universities in each of the eight States bordering the Great Lakes, so some Great Lakes research has been accomplished. For example, the Office has funded

--hydrologic models of the Great Lakes,

--systems analyses of various parts of the Great Lakes, and

--lake aging research.

DEPARTMENT OF TRANSPORTATION

Coast Guard

The Coast Guard's Great Lakes research is limited. The Coast Guard provides aircraft and ship support services to various organizations doing such research and does some inhouse research, primarily to improve ship navigation during the winter months. In addition, through the Federal Water Pollution Control Act Amendments of 1972, the Coast Guard has been given responsibility for research into solid waste disposal equipment for vessels, including Great Lakes vessels.

NASA

NASA is involved in Great Lakes water pollution reseach in that it assists other governmental agencies on request. Because of its expertise in high-altitude, remote-sensing techniques, NASA can develop the methodology for collecting and analyzing data on projects. Although NASA's past involvement in the Great Lakes has been minimal, it may be expanded greatly in the future because of the recent emphasis on applying space technology to help solve the problems of the environment.

NSF

NSF funds Great Lakes research related to water pollution through its research programs carried out primarily at universities and nonprofit organizations. Most of this research supports IFYGL.

MAJOR WATER POLLUTION PROBLEMS
IN THE GREAT LAKES

BACTERIAL POLLUTION

The presence of coliform bacteria in the water, an indicator of certain waterborne diseases, has caused many beaches on the Great Lakes to close. The largest coliform concentrations are usually produced by human contamination, but elevated counts will also occur after rainfalls, due to land runoff and/or storm and combined sewer overflows.

CHEMICAL POLLUTION

The principal source of chemical pollution is industrial waste water effluent which produces two general types of effects: (1) local and immediate effects in the vicinity of the discharge point and (2) a progressive buildup in the concentration of certain persistent chemicals in the lake as a whole. Pollutants being discharged are heavy metals, such as copper, iron, and zinc; phenolic compounds; oil; nitrogenous materials; phosphorus; and chlorides.

DISPOSING OF DREDGED MATERIAL

The Corps of Engineers is responsible for improving and maintaining U.S. waterways for navigation. The Corps annually dredges approximately 10 million cubic yards from Great Lakes harbors. Disposing of these materials in the open lakes may have contributed to the lakes' pollution.

EUTROPHICATION

Eutrophication is the natural aging process of a lake. The process has been greatly accelerated in certain areas of the Great Lakes by the oversupply of nutrients from agricultural runoff and the waste waters of cities and industries.

Source: Federal Water Pollution Control Administration Reports, 1968, 1969, 1970.

MINING WASTE

Mining in the basin is concentrated primarily in the Lake Superior area where, as of January 1970, 151 mines were operating. Water quality problems have been associated with the discharge of waste water from mining activities. Water which seeps or is pumped from mines is extremely turbid and may have a high content of solid particles.

OIL POLLUTION

Discharges from industrial plants and commercial ships and careless practices in loading and unloading cargos contaminate water in many areas. Oil discharges and spills produce unsightly conditions which affect beaches and recreational areas, contribute to taste and odor problems and to treatment problems at water treatment plants, coat the hulls of pleasure craft, and in some cases are toxic to desirable fish and aquatic life.

OXYGEN DEPLETION

The quantity of oxygen normally dissolved in water is perhaps the most important single ingredient for a healthy, balanced aquatic life environment. Dissolved oxygen is consumed by living organisms and is replenished by absorption from the atmosphere and through the life processes of aquatic plants. When pollution enters water the balance is altered. The bacteria already in the water or introduced with pollution use the pollution as food, multiply rapidly, and reduce the dissolved oxygen. The resulting oxygen deficiency, may be great enough to inhibit or destroy fish and other desirable organisms and to convert the stream or lake into an odor-producing nuisance.

PESTICIDES

Pesticides can cause mass death of fish and insidious damage to the reproductive capability of mammals, fish, and birds. The danger from pesticides lies not only in deaths directly attributed to them but in the more subtle or indirect effect which may result from pesticides entering the food chain. Food chains in the aquatic environment are especially vulnerable because they are exposed to land runoff carrying pesticides.

Little data is available on pesticide use in the Great Lakes Basin. However, traces of pesticides have been found in fish taken from Lake Michigan, and several incidents of large fish kills have been attributed to an organic phosphate pesticide potato growers use in the Lake Ontario Basin.

SOIL EROSION

Improper land-use practices have accelerated erosion and watercourse sedimentation in the Great Lakes. Major sources of sediment include agricultural lands and lands involved in highway, subdivision, and other urban construction projects. Sediment is one of the major sources of nutrients. It fills stream channels and drains, necessitates additional expense in treating water supplies, and is detrimental to fish and other aquatic life and water recreation.

THERMAL POLLUTION

Electric generating facilities and many industries use large amounts of water for cooling purposes. Discharges of the heated water may add a considerable waste heat load to the receiving waters, which may impair water uses.

WASTES FROM WATERCRAFT

Vessels of all types--commercial, recreational, and Federal--contribute both untreated and inadequately treated wastes to the Great Lakes.

UNITED STATES GENERAL ACCOUNTING OFFICE

REPORT TO THE CONGRESS

Research And Demonstration Programs To Achieve Water Quality Goals: What The Federal Government Needs To Do

B-166506

ENCLOSURE A

Programs to Determine The Sources, Fate, And Effects of Water Pollutants

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

[illegible]

GLOSSARY

Aeration	The process of being supplied or impregnated with air. Aeration is used in waste water treatment to foster biological and chemical purification.
Algae	Relatively simple unicellular or multicellular aquatic plants, such as seaweeds and pond scums.
Bioaccumulation	An organism's uptake and retention of substances from its environment, as opposed to uptake from its food.
Bioassay	The employment of organisms to determine the biological effect of some substance, factor, or condition.
Biochemical oxygen demand	A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. Large quantities of organic wastes require large amounts of dissolved oxygen. The more oxygen-demanding matter, the greater the pollution.
Chlorinated hydrocarbons	A class of generally long-lasting, broad-spectrum insecticides of which the best known is DDT.
Cooling tower	A device to remove excess heat from water used in industrial operations, notably in electric power generation.
Crustacean	A class of arthropods, including lobsters, shrimps, crabs, etc., commonly having the body covered with a hard shell or crust.
Daphnia	A minute freshwater crustacean, called a water flea.
Dispersant	A chemical agent used to break up concentrated organic material.

Dissolved oxygen	The oxygen dissolved in water or sewage. Adequately dissolved oxygen is necessary for the life of fish and other aquatic organisms and for preventing offensive odors.
Dredging	A method for deepening streams, swamps, or coastal waters by scraping and removing solids from the bottom. The resulting mud is usually deposited in marshes in a process called filling. Dredging and filling can disturb natural ecological cycles. For example, dredging can destroy oyster beds and other aquatic life; filling can destroy the feeding and breeding grounds for many fish.
Ecology	The study of the interrelations of living things with one another and with their environment.
Ecosystem	The interaction of a biological community and its nonliving environment.
Effluent	The waste water discharged by an industry or municipality.
Estuaries	Areas where freshwater meets salt water, e.g., bays, mouths of rivers, salt marshes, lagoons. Estuaries serve as nurseries, spawning and feeding grounds for large groups of marine life, provide shelter and food for birds and wildlife.
Eutrophication	The process whereby a lake becomes overfertilized from too many nutrients, especially phosphorous and nitrogen. As a result, algae and other plant life become overabundant, and the lake may evolve into marshland.
Fossil fuels	Coal, oil, and natural gas, so called because they are derived from the remains of ancient plant and animal life.

Fry	Young or small fish.
Gammarus	A swimming crustacean.
Heavy metals	Metallic elements with high molecular weights, generally toxic in low concentrations to plant and animal life. Such metals are often residual in the environment and exhibit biological accumulation. Examples include mercury, chromium, cadium, arsenic, and lead.
Hydrocarbons	A vast family of compounds containing carbon and hydrogen in various combinations, found especially in fossil fuels.
Inorganic chemical	Any chemical compound not classified as organic; most inorganic compounds do not contain carbon and are derived from mineral sources.
Metabolic	Undergoing metamorphosis or transformation.
Microbes	Minute plant or animal life that cause disease. Some microbes exist in sewage.
Midge	Tiny two-winged fly.
Mollusks	A large group of invertebrates, including chitins, snails, bivalves, squids, octopuses, characterized by the calcareous shell of one, two, or more pieces that wholly or partly encloses the soft, unsegmented body provided with gills, mantle, and foot.
Nitrilotriacetic acid (NTA)	A compound used to replace phosphates in detergents.
Nutrients	Elements or compounds essential as raw materials for organism growth and development; e.g., carbon, oxygen, nitrogen, and phosphorous.

Organic chemicals	Any chemical compound containing carbon; having the characteristics of, or derived from, living organisms.
pH	A measurement used to indicate a material's acidity or alkalinity.
Point source	Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, or tunnel, from which pollutants are or may be discharged.
Potable water	Water suitable for drinking or cooking.
Radioecology	The study of the effects of radiation on plants and animals in natural communities.
Salinity	The degree of dissolved solids in water.
Segment	A portion of a basin, the surface waters of which have common hydrologic characteristics (or flow regulation patterns) and common natural physical, chemical, and biological processes, including reactions to external stresses.
Suspended solids	Small particles of solid pollutants in sewage or natural waters that contribute to turbidity.
Toxicity	The quality or degree of being poisonous or harmful to plant or animal life.
Toxicology	A science that deals with poisons and their effect on living organisms and with substances otherwise harmless that prove toxic under particular conditions.
Turbidity	A cloudy condition in water caused by the suspension of silt or finely divided organic matter.
Water quality criteria	Levels of pollutants that affect the suitability of water for a given use.

Water quality standard	A plan for water quality management which considers the use to be made of the water, criteria to protect the water, implementation and enforcement plans, and an antidegradation policy to protect existing high-quality waters.

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ABBREVIATIONS

AEC	Atomic Energy Commission
EPA	Environmental Protection Agency
NSF	National Science Foundation
p.p.b.	parts per billion

CHAPTER 1

INTRODUCTION

This enclosure presents material on our review of Federal processes-and-effects research concerned with determining the sources and fate of pollutants in both fresh and marine waters and their effects on man and his environment. This research is intended to support operational needs of the Environmental Protection Agency (EPA)[1] and State agencies concerned with water quality and effluent standards, enforcement, planning, and technical assistance.

RESEARCH ON PROCESSES AND EFFECTS OF WATER POLLUTION

Research on the processes of pollution is concerned with the sources, fate, and effects of pollutants in the environment and determining mechanisms by which they pass through the food chain and related ecosystems. Information from research on the transfer, dispersion, reactions, and ultimate fate of pollutants in water and soil is necessary to (1) understand and predict the movement, accumulation, longevity, and breakdown of material in the aquatic and land environment and (2) ascertain the threat they pose to man. According to EPA, much more needs to be learned about the movement and fate of a wide variety of wastes--dredging material, sewage sludge, and industrial waste--dumped into estuaries and oceans.

Research on the effects of pollution is concerned with determining effects on man, animals, plants, materials, and the general environment. Major aspects of this research include investigations of the toxicity of organic chemicals and inorganic chemicals, including mercury, cadmium, lead, and other heavy metals, and studies on the temperature tolerance of different species of fish and other aquatic life. This research is essential in developing new and improved water quality criteria and standards which define acceptable exposure levels and can serve as the basis for regulatory action. According to EPA, the environmental effects of pollutants are far from completely known and such knowledge is essential to improve water quality standards.

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[1] EPA and its predecessor agencies. (See app. III, vol. I.) Processes-and-effects research is administered by the Ecological Processes and Effects Division, Office of Research and Development. (See app. VIII, vol. 1.)

EPA's initial objective under the 1972 amendments of the Federal Water Pollution Control Act, was to assist the States in revising their interstate water quality standards and in developing their intrastate standards to meet the water-use objectives set forth in the amendments.

These standards, together with effluent limitations to control industrial and municipal waste discharges, will play an important role in implementing these objectives.

FEDERAL AGENCIES AND FUNDING

During fiscal years 1969-73, EPA funded about $68 million for research on pollution processes and effects.

Fiscal year	In-house research	Grants and contracts	Total
	(millions)		
1969	$ 2.3	$ 5.8	$ 8.1
1970	5.0	5.5	10.5
1971	5.3	7.4	12.7
1972	8.3	8.8	17.1
1973	11.0	8.9	19.9
Total	$31.9	$36.4	$68.3

The Atomic Energy Commission (AEC) expended about $20 million from 1969 through 1973 on processes-and-effects research to understand the fate and movement of radionuclides in marine waters from atmospheric testing of nuclear devices and from nuclear reactors. The Departments of Commerce and the Interior, and the National Science Foundation (NSF) also funded processes-and-effects research projects, but we were unable to determine their funding levels because they do not classify research expenditures in this manner.

SCOPE OF REVIEW

We reviewed processes-and-effects research to determine the extent it furthered established legislative and agency goals and was used to meet EPA operational needs.

We concentrated on EPA's program because EPA did most of the research and is the Federal agency primarily responsible for protecting the aquatic environment. We reviewed other Federal agencies' research programs to determine the extent of their efforts and the adequacy of interagency coordination.

We selected the following five major research areas for review:

--Effects of pollutants on freshwater life.

--Effects of pollutants on marine life.

--Fate of pollutants in marine waters.

--Lake eutrophication (excessive fertilization of lakes).

--Thermal pollution.

We employed two consultants to assist us in evaluating EPA's research programs on the fate of pollutants in marine waters and thermal pollution.

The review was carried out at headquarters offices of EPA, AEC, and the Departments of the Interior and Commerce. We did fieldwork at EPA's National Environmental Research Center, Corvallis, Oregon; Pacific Northwest Environmental Research Laboratory, Corvallis; National Water Quality Laboratory, Duluth, Minnesota; National Marine Water Quality Laboratory, West Kingston, Rhode Island; and the Department of Commerce's Milford Laboratory, Milford, Connecticut. We also visited 7 EPA regional offices and various agencies in 16 States.

CHAPTER 2

OUR NATION'S WATER POLLUTION PROBLEMS

EPA's 1970 study showed that 27 percent of America's stream and shoreline miles was polluted. In 1971, EPA found that about 29 percent was polluted.

The Council on Environmental Quality, in its third annual report, dated August 1972, stated that there were mixed trends in water quality. The problem of nutrients (phosphorus and nitrogen) had worsened dramatically in all types of river basins, probably because of increased use of fertilizer. Oxygen-demanding wastes had increased somewhat, mostly in populated highly industrialized river basins. The problem of suspended solids in the water seemed to be getting better.

A conclusion contained in the report concerned the effect of streamflow on pollution. The common notion is that increased streamflow, from rain or melting snow, dilutes pollution and helps restore natural balances--unless the rain washes through areas which are sources of pollution, such as fields sprayed with pesticides.

The report shows, however, that in areas of high population and/or industrialization, pollution was diluted by increased streamflow in only 20 to 30 percent of the sampled basins. In other words, industrial and municipal discharges, as point sources of organic and nutrient pollution, appear to be more than equalled by nonpoint sources, such as runoff from farms, feedlots, and possibly urban areas or from scouring of pollutants from riverbeds by high flow. In essence, the report indicated that, even if all discharges of municipal and industrial pollution were stopped, discharges from nonpoint sources would still pollute many streams.

SOURCES OF WATER POLLUTION

Although much pollution comes from nonpoint sources such as agriculture, municipalities and industry contribute substantially to water pollution. Industrial effluents contain an untold variety of inorganic wastes, and organic wastes are growing at a rapid rate. The United States has about 300,000 water-using factories requiring over

30 billion gallons of water daily, excluding water for power generation. Organic wastes from these industries are estimated to have a pollution strength three to four times greater than the domestic sewage handled by all municipalities. At the same time, new synthetic chemicals being developed will form new types of wastes.

Municipal effluents contain large amounts of organic materials, dissolved minerals, and often residues from industrial wastes treated by municipal waste treatment plants.

The effects of agriculture, as a source of water pollution, include field runoff on streams, animal wastes, concentrations of pesticides and herbicides from land runoff, and salinity from irrigation. To attain higher agricultural productivity, irrigation and use of chemical fertilizer and pesticides have been encouraged. Agricultural runoff into streams carries salts and chemicals, many of which are highly toxic and have long-lasting environmental effects. U.S. production of synthetic organic herbicides and insecticides increased rapidly between 1960 and 1970.

The discharge of cooling waste water from power-generating plants, both fossil-fueled and nuclear, is the greatest source of thermal pollution to our waterways. Each year power-generating plants use about 40 trillion gallons of water--or about 10 percent of the Nation's entire river and stream waterflow--for cooling. At points of discharge, the receiving water's temperature increases by an average of 15° F. Because of the constantly increasing demand for power, the potential for thermal pollution is expected to increase nearly ninefold by the year 2000.

Because of the prominence of power plants as a thermal pollution source, many Federal and non-Federal organizations have studied the power industry's rate of growth. These studies show that, in the United States, electric power generation has approximately doubled every 10 years since 1900 and that the rate of increase will probably be even greater in the future. Although population growth is responsible for part of this expanding need, the per capita consumption of electric power has been increasing about five times as fast as population growth.

Below are some major effects that may result from waste water discharges by steam-generating plants according to various research reports.

--Aquatic life dies, especially where temperatures change significantly in a short time.

--Fish may hatch earlier in the spring, before the organisms on which they feed are available.

--Aquatic life becomes more sensitive to toxic substances.

--The amount of oxygen which can be dissolved is lowered, which in turn causes aquatic life to suffer and hinders the natural biological degradation of organic pollutants.

--The value of the water to downstream users is decreased.

Available data indicates that most fish try to avoid lethal water temperatures. Nevertheless, according to several federally funded research reports, many fish have died from thermal pollution as shown by the following table.

Dates of kill	Approximate location	Estimated amount of fish killed
August 1962	Saxton, Pa.	3,000
August 1962	Ladue, Mo.	several thousand
September 1963	Rockford, Ill.	several thousand
May 1964	Victoria, Tex.	several thousand
August 1965	Reading, Pa.	1,000
August 1965	Montgomery City, Ohio	11,000
September 1966	Philadelphia, Pa.	50,000
January 1967	Sandusky City, Ohio	300,000
January 1967	Erie City, Ohio	69,000
January 1968	Fremont, Ohio	251,000
June 1969	Turkey Point, Fla.	several thousand
January 1970	Northport, N.Y.	10,000
January 1970	Biscayne Bay, Fla.	millions
February 1971	Yorkhaven, Pa,	15,000
June 1971	Thompkins Cove, N.Y.	1,000
July 1971	San Onofre, Calif.	5 to 6 tons
January 1972	Oyster Creek, N.J.	massive kill
Monthly (note a)	California shoreline between Ventura and San Diego	4 to 25 tons

[a] February 1972 estimate.

MAGNITUDE OF WATER POLLUTION

The 1972 amendments define water pollution as the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water. Every part of the Nation has some water pollution, but it is more severe in some areas than in others. In 1971, almost twice as many polluted stream-miles were east of the Mississippi River as were west of it. The Ohio, Great Lakes, and Southeastern river basins contain 24 percent of the Nation's stream-miles and 49 percent of the polluted stream-miles.

Rivers and streams

The effects of water pollution can be seen in both urban and rural areas--surface oil slicks, large fish kills, or public health notices warning citizens not to swim or wade in the water. However, water pollution may also create less visible changes in the aquatic life of a river, by decreasing sport and commercial fish and by increasing tolerant but less desirable life forms. Aquatic organisms may be many times more sensitive than humans to the same pollutant.

As population and technology increase, the demands for water and the production of wastes which threaten the environment will also increase. For example, it is estimated that approximately 500 new compounds are produced each year in the United States, which could ultimately lead to significant environmental contamination. The magnitude and primary causes of stream pollution throughout the country as of 1970 are shown in the following chart.

Prime causes in descending rank	Percent of stream pollution						
	United States	Pacific Coast	Northern plains	Southern plains	Southeast	Central	Northeast
Industrial wastes	23.7	12.7	21.0	9.2	34.7	21.5	33.5
Municipal wastes	21.8	13.0	15.6	14.2	21.2	28.5	27.1
Agriculture	11.2	19.1	28.8	27.6	1.3	5.8	.5
Other (note a)	3.7	11.8	.6	16.6	1.7	.4	-
Mining	2.8	2.4	2.6	12.6	.3	4.9	2.6
Other urban wastes	.9	-	-	.1	.7	1.9	1.3
Power generation	.4	1.5	-	-	.6	.6	.1
Spills	.1	-	-	-	-	.2	-
Total	64.6	60.5	68.6	70.3	60.5	63.3	65.1

[a] Divided into three principal classes: water management in highly regulated streams of the West; promotion of sedimentation by construction; and transportation, principally navigation, including stream dredging.

Source: "The Cost of Clean Water," EPA's 1971 report.

The chart shows only the eight prime sources of man-caused pollution. The remaining 35 percent of stream pollution is attributed to natural causes. Water pollution can rarely be traced to a single source, and in most cases, all eight sources occur in the same waterways.

Oceans and estuaries

Oceans cover more than 70 percent of the earth's surface and make our planet habitable by contributing to the atmospheric balance of oxygen and carbon dioxide and by affecting global climate.

Coastal waters, including estuaries, are the most important part of the marine environment related to human use. About 60 million tons of fisheries products are harvested annually from which over two billion people receive 50 percent or more of their animal protein. It has been estimated that more than half of the fishery products harvested by U.S. fishermen are from animals which are dependent for their existence on clean estuary waters at some point in their life cycle.

These same waters that are so essential to us as a source of food and recreation have received much of man's liquid-borne waste materials as well as some of the atmospheric-borne and solid wastes. The total effect of wastes on the marine environment is not known, but certain marine resources have been directly affected. For example, the National Academy of Sciences, in its 1972 report "Marine Environmental Quality, Suggested Research Programs for Understanding Man's Effect on the Oceans," stated that one-fifth of the United States' 10 million acres of near-shore shellfish grounds have been closed because of pollution.

Lakes

Lakes grow old and eventually "die" by becoming filled with the remains of plants and animals that have lived in them and with materials washed in from adjacent lands. Under natural conditions, this aging process occurs slowly over hundreds or thousands of years. Many lakes in the United States have already been aging for some 12,000 years since the time of the continental glaciation. Unfortunately, man can intercede at any moment in a lake's lifetime to compress natural, long term changes into a few decades, resulting in excessive fertilization and accelerated eutrophication.

Excessive fertilization of lakes is caused by man's activities, such as agricultural and recreational development, urbanization, and the discharge of sewage and industrial wastes, which greatly increase the rate at which plant nutrients--particularly nitrogen and phosphorus--are added to the water. This stimulates the growth of excessive quantities of algae and waterweeds and can deplete dissolved oxygen in lower depths, kill fish, shift the fish population from desirable species to unwanted species, and will eventually fill the lake with rooted vegetation.

The exact magnitude of excessive fertilization in the United States is not known, but it occurs in every State. EPA research officials have stated that many of the Nation's estimated 100,000 small lakes are already growing excessive quantities of algae and waterweeds and are in serious trouble. Many reservoirs, estuaries, and slow-moving streams are also subject to accelerated eutrophication, and some have also begun to overproduce unwanted algae.

CHAPTER 3

SCIENTIFIC KNOWLEDGE NEEDED TO SUPPORT WATER POLLUTION CONTROL PROGRAMS

What major pollutants affect the elements on which aquatic life depends? Where do they come from? What do they do to our health and well-being and to the food chain? What should be known about water pollution to protect and enhance the quality of the Nation's waters? These are some of the questions that processes-and-effects research must answer to support water pollution control programs authorized by the 1972 amendments and EPA and States' operational needs in setting water quality standards and taking regulatory action.

EPA has developed scientific data on some pollutants' lethal, sublethal, and safe levels and the ways in which some pollutants enter and move through the aquatic environment. But it has provided little of the scientific knowledge needed to support water quality standards, enforcement, and discharge permit programs.

Research is also needed on the engineering aspects of thermal discharges to predict and assess their nonorganic effects and to develop systems for safely managing them. EPA's research into the engineering aspects of thermal discharge has been limited to one of five programed research areas--physical fluid prediction. Most of these research results have not been tested in actual situations.

Both preventative and remedial measures are needed to solve the problems of accelerated eutrophication of the Nation's lakes. Although EPA has directed research toward most of the identified research needs, EPA does not expect to have sufficient research results to understand and solve this problem until 1979 or later.

DEVELOPMENT OF WATER QUALITY CRITERIA

Water quality criteria are developed by EPA and others through scientific investigations which determine the levels of pollutants that affect the suitability of water for a given use. EPA and the States need these criteria to establish sound and enforceable water quality standards. Water quality standards protect aquatic life by limiting the amount of pollutants that can be present in a body of water having an approved use, such as the propagation of fish for recreational or commerical value.

EPA officials said they had completed little of the process-and-effects research needed to develop water quality criteria. They believe this research will be a never-ending effort because of the (1) introduction of hundreds of new potential pollutants, such as synthetic chemicals, each year, (2) complex nature of water pollution, and (3) limited amount of research funds. Consequently EPA officials were unable to estimate the total cost and magnitude of required processes-and-effects research.

The National Academy of Sciences, in its 1972 draft report on "Research Needs in Water Quality Criteria," stated that scientific data in some areas was lacking, inadequate, or conflicting and restricted development of precise quantitative water quality criteria. The Academy identified six broad areas of research it believed should be considered as high priorities.

1. Acute and cumulative effects of organic compounds on plant and animal life.

2. Effects of metals in water.

3. Development of bioaccumulation and concentration factors for many potential harmful constituents of water.

4. Interaction of pollutants, especially metals and organic chemicals.

5. Ecosystems analysis--understanding the effects of pollutants on communities or organisms and the impact of water quality on the total escosystem.

6. Relationship between microbial quality of water and human health.

Before fiscal year 1973, EPA had directed considerable effort in researching the effects of metals in water but had not directed much of its effort toward the other areas. In fiscal year 1973, EPA funded research projects in all of these areas.

Our consultants stated that, to fully understand the magnitude of water pollution and ways to control it, research is needed to determine how pollutants interact in the water and how such interactions affect aquatic escosystems and human health. Our consultants identified one research area as being extremely important--determining the effects of water pollution on man.

The Department of Health, Education, and Welfare and EPA made a joint study on the health effects of environmental pollution, and in January 1972 the President transmitted their report to the Congress. The report concluded that more research was needed to (1) identify agents entering the environment, (2) assess their toxicity on man's biological systems, (3) develop new testing techniques to detect new agents before they are widely distributed, and (4) develop a scientific understanding of the effects combinations of chemicals have on health.

EPA has conducted little water pollution health-effects research, with funding ranging from $300,000 in 1969 to about $15,000 in 1972. EPA's funding for health effects research in fiscal year 1973 was only about $97,000.

EPA is also performing health-effects research associated with drinking-water supplies and is currently studying diseases associated with water-based recreation. EPA funded about $1.2 million in fiscal year 1972 and $1.3 million in fiscal year 1973 for these studies.

In its May 1973 report to the Congress entitled "Clean Water," EPA stated:

> "Major attention must be afforded health effects in the development of water quality standards. Accordingly, EPA has assigned priority attention to research activities in this problem area. Current research stresses the health effects of chemical and infectious contaminants in drinking and recreational water. During 1973 and 1974 emphasis

will be placed on an assessment of the toxic effects of trace minerals in the environment."

Freshwater

Freshwater pollution problems are caused mainly by municipal, industrial, and other waste discharges. Elements in water can interact in an infinite number of combinations and can change the level at which a pollutant is harmful to aquatic life. At the present time, the understanding of the interactions is poor.

During fiscal years 1969-72, EPA funded about $17 million--$7 million in-house and $10 million extramural--on research to develop freshwater quality criteria. This effort was administered by EPA's National Water Quality Laboratory, Duluth.

Most of EPA's freshwater research is directed toward determining tolerance levels, safe levels, and long term exposure effects of such pollutants and factors as temperature, dissolved oxygen, heavy metals, pesticides, and others on aquatic life.

Although some sound scientific data to develop fresh water quality criteria has been produced,

--research results will, upon completion of current research plans, have barely scratched the surface in meeting freshwater quality criteria needs,

--research needs identified by the National Academy of Sciences remain to be satisfied,

--major EPA objectives remain to be completed, and

--one high-priority research effort to find possible safe alternate disinfectants to chlorine has been delayed and cut back.

There are over 100 elements from which all substances are formed, and those elements singly or combined, can pollute water. There are currently thousands of such potentially harmful pollutants, and new pollutants are being developed faster than the effects of existing pollutants can be determined.

According to the director of the Duluth laboratory, there are approximately 1,500 species of freshwater fish and 5 to 10 times that number of species of other aquatic life in the United States. Except for qualified generalizations, results from testing one species of fish cannot be directly transferred to another. The level at which a pollutant is harmful can differ for any of the thousands of species and also for each of their life stages; therefore a pollutant must be individually tested for each species of aquatic life to determine its safe concentrations. A bioassay to determine a pollutant's safe concentration for the life stages of one species may require up to 3 years. However, bioassays do not account for processes that naturally occur within the environment, which can alter the effects of pollutants on life. As a result, EPA needs to validate its laboratory data on the basis of actual field situations.

The laboratory director estimates that, when he completes his planned research in approximately 1983, the laboratory will have carried out less than 1 percent of all the research that could be done to develop water quality criteria. He mentioned, further, that the laboratory is primarily studying each pollutant's main form and not looking into other possible inorganic or organic forms or interactions. In addition, the laboratory is using one source of water--Lake Superior--and, according to the laboratory director, test results for only one major pollutant have been verified in the field.

The director advised us that developing criteria for freshwater aquatic life with a 100-percent accuracy rate would require testing all life stages of all species of aquatic life for each pollutant and combination of pollutants in every type of water, with field verification of all laboratory work. He said such research would involve an astronomical cost. However, in his opinion, it is not necessary to achieve a 100-percent accuracy rate.

The director said the laboratory is planning to develop water quality criteria by determining the safe levels of 30 to 40 common pollutants for 3 species of fish--bluegills, brook trout, and fathead minnows--and 3 species of fishfood organisms--gammarus (scud), daphnia magna, and midge. These species were selected because they are economically important and geographically distributed, and test methods are or could easily be developed.

The laboratory director informed us that past research was concentrated on inorganic chemicals and effects of such water variants as temperature and dissolved oxygen on fish and other freshwater life. However, he said that each inorganic metal, for example, may have many organic forms, some of which have been found to be anywhere from 10 to 100 times as toxic as the inorganic metal. He stated that there is little knowledge of organic forms of metals. As a result, research is needed, first to identify the possible organic forms of substances and secondly to determine their safe levels.

The director also said the laboratory had carried out only a few studies on the effects of interactions of various pollutants and that it had just begun researching the effects of the accumulation of toxic compounds by organisms for pesticides, metals, and organic solvents.

The results of EPA's processes-and-effects research in four freshwater pollution areas follow.

Dissolved oxygen

This research is intended to determine the dissolved oxygen needed to maintain and complete the life cycle of freshwater fish and food chain organisms. The research is scheduled to be completed by July 1979, enabling dissolved oxygen requirements to be set for 22 species of fish and 18 species of fishfood organisms. The laboratory director advised us that short term tests on the egg and fry growth of approximately 11 species of fish and 6 species of fishfood organisms have been carried out.

For example, one laboratory project was designed to establish safe levels of dissolved oxygen for common species of aquatic insects (mayflies, stoneflies, caddisflies, and midges), known to be important as fishfood organisms. It was performed between September 1968 and March 1970 for about $50,000. The project involved 96-hour tests, 30-day survival tests, and 1- to 9-month tests to determine the effects of low oxygen on adult emergence from the larvae stage.

The project results were published in "Transactions of the American Fisheries Society" in October 1972. It suggested a range of safe concentrations of dissolved oxygen for survival and adult emergence of larvae. However, it concluded that to accurately assess the effect of oxygen on aquatic insects, more research on the complete life cycle (i.e., egg to egg) was essential.

Further research on dissolved oxygen is planned to determine by 1978, water quality requirements for the spawning life stage for eight species of aquatic life. The laboratory director said if all the work in the current dissolved oxygen research plan is completed as scheduled in 1979, water quality standards could be set for dissolved oxygen. He explained, however, that at that time they will not have looked at the effects that interactions of pollutants have had on dissolved oxygen.

Heavy metals

EPA's heavy metals research plan is intended to determine the safe levels of individual and interacting combinations of heavy metals, such as mercury, lead, copper, cadmium, chromium, zinc, selenium, iron, nickel, and aluminum on freshwater life. It is directed toward (1) determining safe concentrations of heavy metals for selected aquatic organisms, (2) developing recommendations for controlling and setting mercury standards, and (3) determining toxic metal forms by 1978. The laboratory director informed us that this research is designed to determine the extent of the heavy metals problem. He believed that, even after the planned research is completed in 1978, less than 1 percent of the needed research on the effects of metals will have been met.

The laboratory director informed us in June 1973 that chronic (long term) tests had been carried out over the life cycle of brook trout, bluegill, fathead minnows, and daphnia magna for each of four heavy metals--mercury, copper, cadmium, and chromium. He said that enough work had been done on these four metals to set applicable water quality standards but that the toxicity of the different inorganic and organic forms of only one of these metals (mercury) had been studied and that only limited tests had been made on the interactions of heavy metals. For example, the laboratory was studying the effects of lead on three generations of brook trout. The pictures on page 18 show the effects of lead on second-generation brook trout spawned and reared for 1 year in control water and in water containing 125 parts per billion (p.p.b.) of lead. The parents of the deformed fish were exposed to lead 7 months before their spawning.

The laboratory director told us that by 1975 he hopes to have basic toxicology information for setting water quality standards for the inorganic forms of mercury, lead, copper, cadmium, chromium, zinc, selenium iron, nickel, and aluminum. He stated that the criteria will be based on chronic tests using daphnia magna, brook trout, and fathead minnows.

Pesticides

The objective of pesticides research is to determine the safe level for pesticides in the freshwater environment. The goals of this work are to provide water quality criteria for 12 or 13 pesticides by June 1974, obtain insight into the significance of food chain accumulation of persistent pesticides, establish criteria for additional species of aquatic life and important synthetic organic (pesticide) substances, and field verify the applicability of certain laboratory data by June 1977. The laboratory director informed us that, by December 1973, at least one chronic test will have been made on one to six aquatic species, using eight or nine pesticides.

The laboratory director said that the laboratory had not studied interactions of various pesticides in water and their effect on aquatic life or the intermittent exposure of those pesticides to aquatic life.

One of the laboratory's pesticide projects was directed toward determining the effects of carbaryl (widely used as an insecticide) on growth, survival, and reproduction of the fathead minnow throughout its entire life cycle. An article containing research results from this project was published in the "Journal of Fisheries Research Board of Canada" in 1972. The article reported that the maximum acceptable toxicant concentration for carbaryl lies between 0.21 and 0.68 milligrams per liter.[1]

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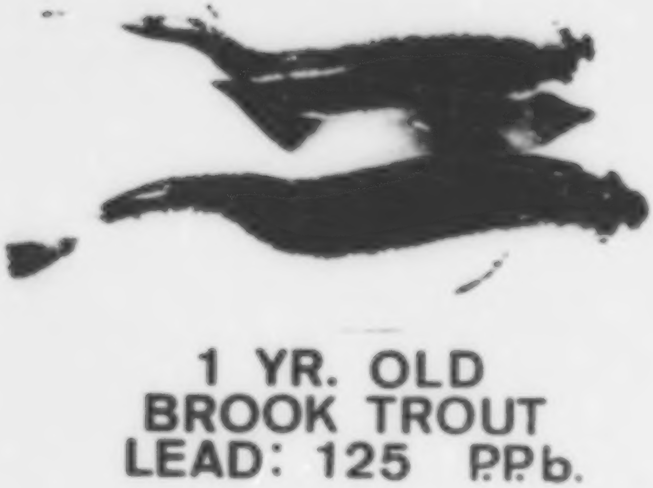
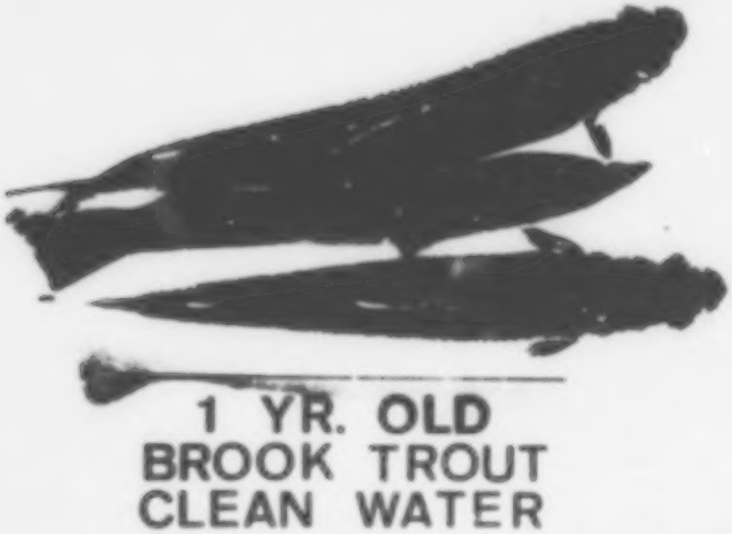
[1] 1 milligram per liter is equivalent to about 1 tablespoon of water added to about 5,000 gallons of water.


1 YR. OLD
BROOK TROUT
LEAD: 125 P.P.b.

SPINAL DEFORMITIES DEVELOPED IN BROOK TROUT EXPOSED TO 125 p.p.b. LEAD


1 YR. OLD
BROOK TROUT
CLEAN WATER

NO APPARENT DEFORMITIES IN BROOK TROUT REARED IN CLEAN WATER

(EPA photograph)

The laboratory director informed us in June 1973 that five extramural research projects were underway to investigate the effects of certain pesticides--parathion, diazinon, chlordane, lindane, toxaphene, and atrazine--on six major species of aquatic life. These projects are scheduled to be completed between June 1973 and April 1974. The laboratory director said that, depending on the results of these projects, followup research may involve chronic tests on only one of the six species of fish and one species of fish-food organism and acute (short term) tests on the other species. He noted, however, that pesticides research will continue because new pesticides are being manufactured.

Chlorine

In 1970, EPA found that chlorine, the only generally accepted disinfectant used by municipal waste treatment plants, was harmful to aquatic life. In 1971 EPA performed research to determine whether chlorination or alternate processes, such as ozonation or dechlorination, should be used when disinfecting municipal wastes. At that time, there was little research data on the cost, effectiveness, and potential impact of alternate disinfectants.

Because of the anticipated construction of large numbers of waste treatment plants as a result of increased funds provided by the Congress for the Federal construction grant program, EPA decided to take immediate steps to deal with the chlorination issue. It approved the following research objectives in April 1971, with a planned completion date of 1973.

1. By November 1971, determine the specific locations where chlorinated effluent is causing, or could cause, significant pollution problems from new municipal waste treatment facilities.

2. By December 1971, determine the effects of chlorinated and ozonated effluents on freshwater aquatic life, and by July 1972, determine the effects of chlorinated and ozonated effluents on marine life.

3. By January 1973, assess, develop, and demonstrate alternate disinfection and dechlorination techniques.

4. By July 1973, establish guidelines and preliminary design manuals for constructing alternative disinfection systems. This was to be done concurrently with the third objective.

As of May 1973, EPA estimated that the research information necessary to make a sound policy decision on using chlorination would not be available until 1979. The first objective was assigned a low priority and was not pursued. The freshwater effects research of the second objective was underway and is estimated to be completed in June 1974, a delay of 2-1/2 years; only a small part of its marine effects research had been funded and no additional work is planned. The third objective was in progress but, because of late funding, is not expected to be completed until 1979, a delay of about 6 years. Finally, since work to accomplish the fourth objective was to be concurrent with the third, it also will probably not be completed until 1979.

Officials of EPA's Office of Water Programs informed us that its current policy was to recommend that municipalities use a disinfectant for municipal sewage treatment plants but not specify the disinfectant to be used.

Research into the fate of pollutants in marine waters

During fiscal years 1969-73 EPA funded about $4 million to determine the fate of pollutants in marine waters. The overall objectives of EPA's program are to improve the scientific understanding of pollutant behavior in the marine environment and provide a rational basis for marine water quality criteria and waste discharge decisions. According to program officials, these objectives are being researched in four major areas.

1. Developing predictive techniques and models to describe the time-space distribution of pollutants as influenced by physical transport and dispersion, chemical and biological interactions, and transformations.

2. Evaluating the acceptability of waste materials proposed for marine disposal.

3. Identifying acceptable discharge sites for disposable materials.

4. Finding beneficial uses for waste materials discharged into the marine environment.

The program director stated that the program is in its initial stages compared to the processes-and-effects research on rivers and lakes that has been going on for many years. He said that no attempt has been made to determine the total research needs. One of our consultants reviewed EPA's fiscal year 1973 plans and objectives and concluded that collectively they represented the most significant needs in marine research. He advised us, however, that the plans addressed only a small portion of the research needs outlined in a 1972 draft report by the National Academy of Sciences' and the National Academy of Engineering's Marine Aquatic Life and Wildlife Panel of the Committee on Water Quality Criteria. For example, he said that additional research, not included in EPA's plan, is needed on the characteristics of dredge spoils to develop criteria for dredging methods and establish requirements for proper disposal.

In 1970 the Academies recommended the following minimum research for the next 10 years.

Area of need	Estimated man-years
Improve waste discharge and monitoring programs	210
Investigate physical processes and interactions	720
Determine chemical factors	450
Determine biological effects	1,280
Total	2,660

On the basis of $25,000 per man-year, this would represent about $66.5 million in funding.

EPA's program director informed us in June 1973 that no attempt had been made to determine the total research needs but that about 1,800 man-years of the research identified by the Academies would be within the scope of his program.

Predictive techniques

During fiscal years 1969-72, most of the fate of pollutants research effort was directed toward developing predictive techniques that describe the physical transport and dispersion processes of pollutants discharged into marine waters. Of the 15 reports published during this period, 14 were concerned with predictive physical transport and dispersion.

Little research has been done to develop predictive techniques for chemical or biological interactions and transformations of wastes, sludges, and debris discharged into the sea. Research in this area was initiated in fiscal year 1973.

EPA's 1973 plans for research on marine predictive techniques showed the following funding.

	Funding through fiscal year 1972	Planned funding fiscal year 1973 through fiscal year 1978	Total funding through fiscal year 1978
		(000 omitted)	
Research on estuaries	$ 542	$ 2,305	$ 2,847
Research on oceans	2,320	14,977	17,297
Total	$2,862	$17,282	$20,144

In the opinion of one of our consultants, EPA's planned funding levels are inadequate. For example, he considered EPA's financial support ($2.8 million) for developing predictive models for estuaries as being about the level required to properly describe the process in only one major estuary.

Estuaries present one of the most complex water quality management problems. For predictive modeling in the ocean environment, there is an infinite number of conditions to be modeled. The problem is to select, within the resources available, only the most important conditions for study.

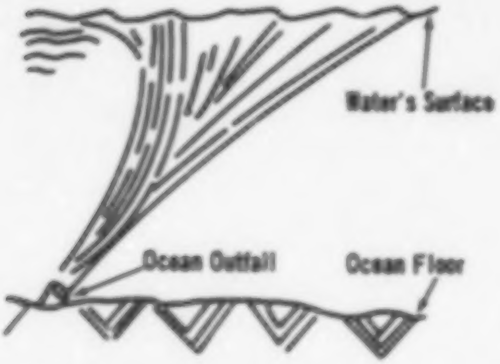
It is important that EPA's plans include verification of the predictive models being developed. Currently, those involved in using existing models and studies disagree about their validity.

One of EPA's most successful research projects in the predictive modeling area is entitled "User's Guide and Documentation for Outfall Plume Model" published in May 1971. This guide provides a computational program for analyzing pipeline discharges into oceans, estuaries, lakes, or reservoirs and a standard procedure for predicting the behavior of the discharged wastes.

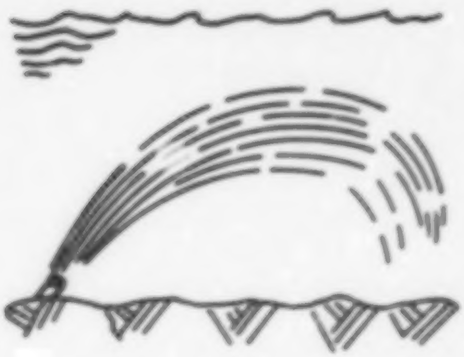
Through the use of pipeline size and force of flow data, this model is capable of predicting the direction and height of a waste pattern along with the waste concentration at various locations in the pattern. This data, in combination with scientific information on the effects of the various pollutants on the marine environment, provides the scientific data needed to make valid decisions regarding proposed waste discharges into the marine environment.

The following drawings show four possible patterns of discharged wastes that can be predicted using this model.

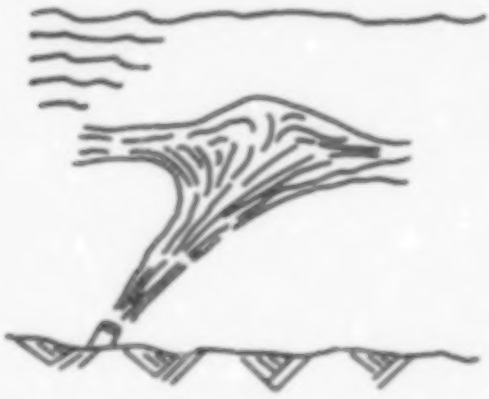
FOUR POSSIBLE WASTE DISCHARGE PATTERNS WHICH CAN BE PREDICTED


Water's Surface
Ocean Outfall
Ocean Floor

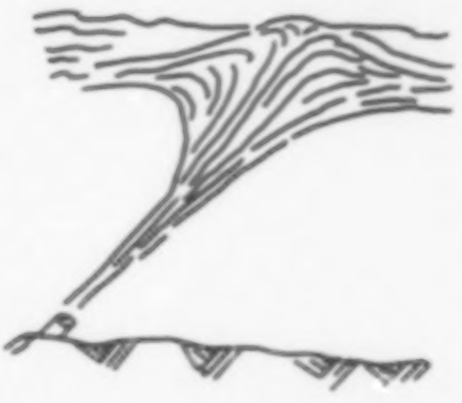
DISCHARGED WASTES RISE TO WATER'S SURFACE



DISCHARGED WASTES RISE, NOT REACHING THE SURFACE, AND THEN DESCEND TO LOWER DEPTH



DISCHARGED WASTES RISE AND REACH POINT OF EQUILIBRIUM BELOW WATER'S SURFACE



DISCHARGED WASTES RISE TO SURFACE BUT LATER SETTLE AT POINT OF EQUILIBRIUM BELOW THE WATER'S SURFACE

Acceptability of materials for marine disposal

In 1973, EPA started research on the acceptability of selected materials for marine disposal. Research is to be performed on individual pollutants in materials proposed for marine disposal. For example, research is planned on the behavior of mercury and cadmium in sewage sludge, the results of which will provide the scientific data needed for regulating ocean dumping and pollutant discharges into the ocean. The program director said no studies had been completed that would provide the scientific data needed for approving or disapproving the discharge of any pollutants into the oceans. EPA approved about $687,000 for this research in 1973 and estimated that it would spend about $12.6 million in fiscal years 1974-78.

The need to research ocean dumping in the marine environment was brought out by the President in his April 15, 1970, message to the Congress on waste disposal. At that time, the President directed the Council on Environmental Quality to determine the research and legislative needs for dealing with ocean disposal. In October 1970, the Council published the report entitled, "Ocean Dumping a National Policy," and recommended a national policy to (1) ban unregulated ocean dumping of all materials and (2) strictly limit ocean disposal of any materials harmful to the marine environment. The Council also recommended that legislation be passed requiring EPA to issue permits to control ocean dumping and that research be carried out to provide the scientific data needed to manage the program. The 1972 amendments to the Federal Water Pollution Control Act and the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1401 (Supp. II, 1972)) authorized EPA to ban ocean dumping of certain materials and to establish a permit program.

EPA, in its budget proposal to the Congress, requested $450,000 for fiscal year 1972 to initiate the marine disposal control program and $1.6 million to investigate the effects of wastes dumped or discharged into the oceans. The research on the marine disposal program was funded initially for $1.5 million in fiscal year 1972. According to the program director this funding level was necessary to meet identified research needs. The funding was subsequently reduced by EPA headquarters to about $510,000, and all but two of the proposed major grants and contracts were postponed.

For fiscal year 1973, the program director requested $2.4 million to expand the marine disposal research program, of which $2.2 million, in his opinion, was required to achieve a minimum acceptable level of output. EPA headquarters reduced the funding again in 1973 to $687,000, postponing two major extramural research studies on ocean dumping.

The program director said that, as a result of these funding reductions, EPA has been unable to perform the studies necessary to establish a scientific basis for ocean dumping guidelines. He said that EPA's criteria for ocean dumping issued in May 1973 to meet legislative mandates were, for the most part, based on judgments rather than on adequate scientific research.

Our consultants expressed the opinion that adequate technical data is not available for EPA to develop final guidelines on ocean disposal. One of our consultants stated that this research is important, not only to carry out the mandate of the Congress, but also because relatively little research has been done on ocean dumping. He said that research in this area will take many years and substantial funding and that, although this is the most significant area in the marine fate program, actual funding has not permitted satisfactory progress.

Identifying acceptable ocean dumping sites

The program director stated that EPA was not identifying acceptable ocean dumping sites nationwide. EPA identifies acceptable sites only when communities request it. He stated that New York and Philadelphia are the only two cities receiving this type of assistance.

Beneficial marine uses for wastes

In fiscal year 1973, EPA started research on finding beneficial marine uses for wastes. The initial plans requested $25,000 for 1973, with planned funding of $1.4 million through 1978. In 1973, EPA approved $3,000 for a literature search to find out what other agencies had done in this area.

The program director informed us in May 1973, that EPA headquarters rejected funds requested for further research on beneficial uses in 1974 and that no further work was planned.

Research into the effects of pollutants in marine waters

During fiscal years 1971-73, EPA funded about $9 million to determine the effects of pollutants in marine waters.

Fiscal year	In-house research	Extramural research	Total
	(000 omitted)		
1971	$1,028	$1,378	$2,406
1972	1,480	1,518	2,998
1973	1,841	1,763	3,604
Total	$4,349	$4,659	$9,008

Since 1967, EPA's National Marine Water Quality Laboratory at West Kingston has been responsible for effects research to develop water quality criteria for marine life of U.S. estuarine and coastal areas. The laboratory has emphasized three areas:

1. Ecological research--to determine the biological requirements for temperature, dissolved oxygen, salinity, pH, current, light, turbidity, and other factors in the ecosystem. The research is planned for completion in 1978 at a cost of about $15.5 million.

2. Toxicological studies--to determine the effects of heavy metals on estuarine and marine species. The purpose of these studies is to determine how much of these metals can be tolerated without harming the organisms or their food chain species or without reducing the species' ability to survive and reproduce. The research is planned for completion in 1978 at a cost of about $6.7 million.

3. Bioassay studies--to develop systems for measuring the effects of pollutants on various organisms. The work is planned for completion in 1978 at a cost of about $4 million.

Ecological research

Fiscal year 1973 ecological research focused on developing (1) culture, rearing, and holding techniques capable of producing quality-controlled marine organisms for experimental use, (2) standard facilities and control systems commensurate with these needs, (3) an ecological studies system for field validation of laboratory results, and (4) biological criteria supporting legal standards for dissolved oxygen, temperature, and salinity. No projects or tasks had been completed, but a laboratory official said 24 subtasks had been completed. The official in charge of ecological research stated that about 5 percent of the research was completed.

One current ecological study is directed toward developing a feasibility model for a remote water monitoring system. This system would operate as an onsite marine test platform for such water quality parameters as temperature, dissolved oxygen, and pH. The official in charge of this research informed us that it was started in fiscal year 1971 and is expected to be carried out through 1974 at an estimated cost of $193,000.

A subsurface marine buoy has been designed, fabricated, and installed to serve as a platform for testing and evaluating environmental sensors. Currently, work is in progress to test and evaluate temperature, dissolved oxygen, and pH.

Toxicological and bioassay research

The toxicology research has emphasized (1) biological methods for water quality assessment, (2) establishment of acute and chronic levels of materials--especially heavy metals and petrochemicals--hazardous to marine organisms, and (3) relationships between test organisms and reservoirs of pollutants in their environment. Bioassay research tries to develop methods to measure the effects of pollutants on organisms.

The official responsible for research in these areas said EPA has determined the safe levels of 6 metals, 3 crude oils, 20 or more dispersants, and nitrilotriacetic acid (NTA) for more than 20 species of marine organisms under various environmental conditions over different periods of exposure. He said the results of this research have provided the most useful basis for effective court actions and legislation.

The official concluded that the laboratory had barely scratched the surface of toxicological research. He estimated that, as of April 1973, less than 1 percent of the toxicological research needed was completed and that bioassay research was about 15-percent complete.

One research project in toxicology was recently completed on the interactions of organisms and oil pollution. It was carried out between May 1969 and April 1973 at a cost of about $162,000. Research results, included in a draft report, substantially met the objectives of the project. However, the report recommended that research be extended to include natural conditions, other coastal regions, other types of oil, and more species of marine life and that EPA, in cooperation with public health authorities, establish legal limits for the acceptability of oil pollution in fisheries products. With the additional research recommended, the report concluded that water quality standards could be set for petroleum hydrocarbons.

The laboratory had not completed a major in-house research objective since it began in early 1967. To obtain tangible evidence of output, we requested laboratory officials to identify their accomplishments in quantitative terms indicating levels of criteria or bioassay procedures establsihed in its 5 years of operation.

Laboratory officials stated they were unable to quantify their overall accomplishments because of the complex nature of the research. Both the former and present laboratory director believed, however, that the laboratory's output had helped develop criteria. The laboratory assistant director stated that, in earlier years, laboratory personnel went through learning and building processes for background knowledge and facilities development. The earlier programs outlined broad studies which have slowly evolved into more definite work plans with specific end products. He stated that the present programs have stabilized, and their effectiveness has increased.

Research on the effects of thermal discharges

During fiscal years 1969-72, EPA's Duluth laboratory funded about $2.2 million to study the effects of thermal discharges on fish and fishfood organisms. Its thermal research objectives were as follows:

> "Valid criteria for setting water quality standards for the propagation of freshwater fishes and other aquatic life and wildlife. Program efforts will be directed to develop criteria for fishes, including anadromous[1] fishes, and invertebrates and their food chain organisms, for * * * temperature * * *. Tolerance levels, safe levels, and long-term exposure effects will be determined."

Thermal discharges cause problems in rivers, oceans, and lakes. According to a National Water Commission report, dated June 1973 to the President and the Congress, the effects of thermal discharges resulting from energy production was one of the three highest priority areas needing research.

The EPA photographs on the following pages depict some of the biological effects of thermal discharges from power plants that do not use off-stream cooling techniques.

The program director at the Duluth laboratory prepared a thermal effects research plan for determining the temperature and dissolved oxygen requirements of a selected number of fish species and food chain organisms. The plan was estimated to cost $9.[illegible] million (mostly for temperature research) from fiscal year 1972 through completion in fiscal year 1982. As of January 31, 1973, scientific journals in the United States, Canada, and Great Britain had published articles describing the laboratory's thermal research results during fiscal years 1969-72.

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[1] Fish that typically inhabit seas or lakes but ascend streams at more or less regular intervals to spawn, i.e., salmon, steelhead, or American shad

EPA PHOTOGRAPH

LUSH GROWTH OF TURTLE GRASS ALONG A COASTAL SHORELINE, WHICH PRODUCES COPIOUS AMOUNTS OF ORGANIC MATERIAL THAT (I) IS A SOURCE OF FOOD FOR FISH AND (2) SERVES AS A COVER FOR MANY SMALL FISH AND INVERTEBRATES

EPA PHOTOGRAPH

TURTLE GRASS AREA AFTER EXPOSURE TO POWER PLANT THERMAL DISCHARGES

EPA PHOTOGRAPH

AFTER EXPOSURE TO UNUSUALLY HIGH THERMAL POWER PLANT DISCHARGES, LARGE NUMBERS OF DEAD PISTOL SHRIMP, BOTTOM-DWELLING FISH, SPIDER CRABS, BLUE CRABS, SMALL CLAMS, SNAILS, SPONGES, AND BAY CORALS WERE FOUND

The program director informed us that the laboratory had completed about 25 percent of the planned research; the laboratory was about 1 year behind schedule and had tested none of the research results for actual situations in field locations. He said the primary reason for the slippage was the delayed completion of the Monticello, Minnesota, research facility. This facility was completed in July 1973 and will be used for verifying laboratory-derived data under seminatural field conditions.

The program director informed us that, because of EPA funding limitations at the time the research plan was prepared, a considerable amount of needed research was omitted from the plan. He said about two or three times the current funding level is required to fulfill existing research needs on thermal effects. His overall assessment was that the laboratory and other research groups had met 10 to 20 percent of the Nation's existing thermal pollution research needs.

A major factor limiting EPA's research, according to potential research users in EPA's regional offices and State water pollution control agencies, was that it had been done in a laboratory environment or at sites having considerably different environmental conditions than the bodies of water in the users' regions or States. They believed EPA's research should be redirected toward site-oriented research. One potential user informed us that results from site-oriented research could more logically be used as a basis for making decisions on such matters as State water temperature standards, discharge permit applications, and enforcement actions.

We believe that EPA's thermal research program should include both field and laboratory research programs, with more immediate emphasis on specific site studies to support water quality standards. Some of EPA's research projects on the effects of thermal discharges are discussed below.

Effects of temperature on growth and survival of young brook trout

The Duluth laboratory conducted this research project during a 4-month period. The project expanded on previous research into thermal effects on brook trout, specifically, the influence of temperature on such factors as growth, mortality, and the short term tolerance of brook trout. This research led to a better understanding of the upper temperature requirements for brook trout during their first 8 weeks of life.

The program director considered this project to be one of his program's two most successful thermal research projects. The National Academy of Sciences cited the results of this project in its 1972 Water Quality Criteria draft report.

Studies of the effects of thermal pollution in Biscayne Bay

An EPA grantee conducted this project during a 3-year period at a cost of about $287,000. The purpose of the project was to quantify the effects of thermal discharges on the distribution and abundance of animals and plants in the vicinity of the nuclear power plant at Turkey Point, Florida. At about the same time, the grantee was making related studies for AEC and other Federal agencies, and for a power company at an additional cost of about $1 million.

Although EPA officials questioned the validity of the manner in which the grantee derived some of the research results, they generally believed that the grantee's draft report (which EPA had not accepted for publication as of June 1973) contained much usable research information. We were informed that the grantee's Biscayne Bay research was being used to set Florida's water temperature standards. Also, the research results were presented during enforcement proceedings as evidence of the damage being caused by thermal discharges from the Turkey Point power plant.

CONTROLLING THERMAL DISCHARGES

During fiscal years 1969-72, EPA funded about $2 million to research methods to control thermal discharges. EPA's Corvallis laboratory had the operating responsibility for this research area. In fiscal year 1972, management for most of the research in this area was transferred from the Ecological Processes and Effects Division to the Applied Science and Technology Branch[1] under the heavy and light industrial sources program.

EPA's Program Planning Manual, prepared in March 1972, included the following objectives for the Corvallis laboratory's thermal research program:

> "Improved scientific basis for predicting and assessing the amount, behavior, and non-organic effects of heat discharged to the aquatic environment. The development of environmental systems for safe management of heated discharges, including siting requirements for heat discharging plants and beneficial environmental uses of otherwise wasted heat, will also be undertaken."

The program director at the Corvallis laboratory prepared a plan for developing and verifying predictive models with a funding level of about $1.9 million for fiscal year 1969 through estimated completion in fiscal year 1976. This plan consisted of five major research areas:

1. Physical fluid prediction.

2. Behavior of cooling tower plumes in the atmosphere.

3. Chemical aspects of heat in water.

4. Biological aspects of heat in water.

5. Field verification of predictive models.

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[1] In June 1973, EPA reorganized these research and development activities into the Industrial Pollution and the Non-Point Pollution Control Divisions under the Deputy Assistant Administrator for Environmental Engineering, Office of Research and Development.

The program director believed over 50 percent of the Nation's existing thermal water pollution control problems had been researched through the program. However he also believed that, because of the increase in thermal discharges which is expected to result from greater use of nuclear power plants, EPA has not yet begun to solve the thermal pollution problems which will be present in the Nation's waters 20 years from now.

The program director informed us that, as of April 1973, research had been confined to physical fluid prediction and is expected to be completed about the end of 1973. He said work on the behavior of cooling tower plumes was not scheduled to begin until July 1, 1973, and that no research work had been done on the chemical and biological aspects of heat or on field verification areas because of funding limitations.

RESTORATION OF LAKE WATER QUALITY

During fiscal years 1969-72, EPA funded about $8 million to develop methods to control excessive fertilization and procedures for restoring the water quality of lakes. In mid-1972 EPA also began a 3-year, $3.7 million nationwide lake survey to identify those bodies of water threatened by excessive fertilization that might respond to nutrient control measures.

Both preventive and remedial measures are needed to solve the problems of accelerated eutrophication of the Nation's lakes and other slow-moving bodies of water. Excessive fertilization impairs a lake's uses. The excessive growth of algae interferes with a lake's use for drinking water as well as for recreation, clogs filters in water treatment plants, and causes property values to decline. The following photographs show the results of excessive fertilization.

EPA PHOTOGRAPH

SURFACE OF A LAKE COVERED WITH ALGAE AND SCUM. SUCH EXCESSIVE GROWTHS INTERFERE WITH USE OF THE LAKE FOR RECREATION AND AS A SOURCE OF POTABLE WATER

ROOTED VEGETATION PARTIALLY FILLING A POND. THIS POND MAY EVENTUALLY BE FILLED WITH SUCH GROWTHS AS A RESULT OF EXCESSIVE FERTILIZATION

EPA PHOTOGRAPHS

EPA's lake eutrophication research program includes:

1. Demonstrating and evaluating techniques for controlling nutrient additions from point sources and for reducing nutrients in the water.

2. Developing standard techniques for predicting the response of aquatic organisms to changes in nutrient levels and for categorizing bodies of water with respect to the degree of aging.

3. Developing a better understanding of the fundamental mechanisms involved in excessive fertilization and building predictive models for the process.

4. Developing techniques to measure and control nutrient input from diffuse sources.

5. Demonstrating and evaluating nonconventional methods of restoring bodies of water where nutrients cannot be controlled.

6. Developing biological and chemical means of controlling excessive plant and algal growth where nutrients cannot be controlled.

7. Identifying those bodies of water threatened by excessive fertilization that might respond to nutrient control measures.

Although EPA research is directed toward solving the problems of excessive fertilization, program officials stated that EPA had not, as of July 1973, fully demonstrated and evaluated any of the techniques for point source nutrient control, in-water nutrient reduction, or nonconventional lake restoration techniques and that they did not expect these and other evaluations to be completed until after fiscal year 1979. The program director estimated that research and demonstrations required to adequately meet the need for lake restoration technology would cost $50 million.

EPA research plans do not deal with the need for a detailed, quantitative assessment of excessive fertilization of water nor with research needed on large, complex, multipolluted bodies of water. (Our study of Federal water pollution research and demonstration programs on the Great Lakes is discussed in volume II of our report.)

EPA program officials said that most of the agency's research on control and restoration of lake water quality is directed toward understanding and modeling the accelerated eutrophication process and developing control techniques. Other projects were aimed at techniques for assessing the impact of nutrient additions or reductions on aquatic organisms and categorizing the degree of eutrophication of bodies of water. A few projects involved full-scale demonstration and evaluation of possible techniques for controlling and reversing excessive fertilization.

Understanding and modeling the accelerated eutrophication process

Program officials said that basic research on mechanisms involved in excessive fertilization is intended to fill a void in the understanding of the accelerated eutrophication process and to provide a basis for applied research to model the process and develop control techniques. They said that the research resulted in a better understanding of certain aspects of the eutrophication process but that much more needs to be learned. They said also that 20 of the 41 extramural basic research projects active during fiscal years 1969-72 were informative but had not been used directly for ongoing applied research.

According to program officials, the limited use of these projects' results was attributable to a lack of a sound basis for selecting extramural research projects to be funded during the first few years of the program. At that time there was a tendency to fund any acceptable research proposal aimed at providing information on lake life cycles and excessive fertilization. These officials said that some projects were funded on this basis without a plan as to how they might actually contribute to future efforts to develop control techniques and predictive models.

Program officials said the number of active extramural projects that did not contribute to applied research efforts had decreased during fiscal years 1969-72.

Although many of the extramural basic research projects did not contribute to applied research, program officials said some of the projects did provide a basis for developing initial models which would ultimately lead to predictive models. Although funding for this model building has been very limited, they said that some models are being developed and must later be validated on numerous bodies of water using data before and after restoration programs are initiated. They estimated that predictive models for all waters subject to accelerated eutrophication would not be available until some time after fiscal year 1979.

Assessing nutrient impact and quantifying degree of eutrophication

During fiscal years 1969-72, an extensive in-house and extramural effort was devoted to developing standard methods for assessing how freshwater algae respond to changes in nutrient levels. A standard laboratory assay procedure was developed and is considered a highly successful result. Development of a standard laboratory algae assay procedure required about $400,000 in extramural grants and an estimated 13 man-years of in-house effort costing about $264,000. It provided a basis for predicting the impact of nutrient control experiments on algal growth and is being used extensively in the lake survey program, in other research, and to a limited degree in EPA regional offices.

EPA research officials told us that the assay procedure will play a major role in helping EPA and the States to establish reasonable nutrient standards for freshwater lakes, streams, and reservoirs, as required under the 1972 amendments to the Federal Water Pollution Control Act. They said it should also help the States classify their lakes and develop background data needed before they submit proposals to EPA for grants for nutrient control and lake restoration projects.

Work on continuous flow and field assays has not been completed, and standard salt water assays need to be developed. Work on developing standard procedures and an index for quantifying the degree of eutrophication of bodies of water has been limited. Officials estimate that the needs of this research area will be met by fiscal year 1979.

Controlling and reversing excessive fertilization

Program officials said that several research projects to control nutrients from point sources, reduce nutrient availability in the water, restore lakes through nonconventional techniques, and control excessive algae growth by biological and chemical techniques were conducted during fiscal years 1969-72. Only a few of these projects involved full-scale demonstrations. Some research to measure and control nutrients from diffuse sources was also carried out.

As of June 1973, projects dealing with evaluation of nutrient diversion, advanced waste treatment, nutrient inactivation, aeration, sediment dredging, and sediment drying were in early stages of development. Program officials estimated that these projects and other evaluations would not be completed until after fiscal year 1979.

An extensive in-house effort was devoted to demonstrating and evaluating advanced waste treatment as a lake restoration technique on Shagawa Lake at Ely, Minnesota. EPA spent about 22 man-years and $660,000--excluding construction costs--on this project during fiscal years 1969-72.

The eutrophic condition of Shagawa Lake appeared to be the result of excessive nutrients in waste water discharged from Ely. EPA researched the lake's condition and demonstrated, on a pilot scale, that treating municipal waste water to remove more than 99 percent of its phosphorous would control excessive growths of algae. On the basis of this research, EPA funded construction of a full-scale advanced waste treatment plant at Ely, which began operating in April 1973. The lake is being monitored to document its recovery, and officials estimate that a meaningful evaluation of the project will be possible by fiscal year 1976.

EPA's municipal technology development program has demonstrated processes that remove 80 to 90 percent of the phosphorous from waste water discharges.

Only two projects relating to biological and chemical control of excessive algae and plant growth were underway as of June 1973. According to program officials, this research area was not assigned a high priority.

Research projects to measure and control nutrients from diffuse sources were limited to studies of lake sediments but, according to program officials, will expand to include other sources by fiscal year 1979 or later. Applied research to develop, demonstrate, and evaluate nutrient control techniques for septic tanks and irrigation return flows is also planned, but program officials said it has not been given a high priority.

National eutrophication survey

During mid-1972, EPA initiated a program to identify those lakes and other impounded bodies of water which are threatened by excessive fertilization and which might respond to nutrient control measures. The initial plans for this program proposed expenditures of about $3.7 million for fiscal years 1972-74. EPA funded about $329,000 in fiscal year 1972 and budgeted about $2.1 million for fiscal year 1973.

The survey began in 10 States, was expanded to 17 more States during 1973, and involves collecting water sample data from about 800 lakes nationwide over intervals of 1 year. A total of 242 lakes were sampled in the 10-State area and preliminary findings indicated that a majority are subject to excessive fertilization and potential accelerated eutrophication. Final results will be published as they become available; the reports on far western States are to be issued during 1976. The first reports on lakes in Vermont were expected in the fall of 1973.

RESEARCH NEEDED TO SUPPORT PROGRAMS AUTHORIZED BY 1972 AMENDMENTS

The Federal Water Pollution Control Act Amendments of 1972 established a national goal of eliminating the discharge of pollutants into navigable waters by 1985; an interim goal of water quality which provides for protection and propagation of fish, shellfish, and wildlife, and which provides for recreation in and on the water by July 1, 1983.

To achieve these goals, the amendments provided for establishing water quality standards for all navigable waters and effluent limitations for point sources of pollution.

In February 1973, EPA published policies for implementing the 1972 amendments in a Water Strategy Paper. EPA stated in this and other documents that the principal means of controlling point sources of pollution will be universal effluent limitations based on the best practicable and available control technology. If using this technology will not result in meeting water quality standards, more stringent controls could be imposed. In addition, water quality standards are to be the primary enforcement tool to control nonpoint sources of pollution and to regulate ocean dumping.

Several sections of the 1972 amendments require or authorize EPA to do processes-and-effects research to support legislative goals and to establish standards and guidelines based on water quality criteria. The act authorizes a $20 million thermal pollution study and a $300 million grant program which EPA plans to initiate in 1974 to help States restore the water quality of lakes. (See app. I for a list of legislative provisions.)

In May 1973, EPA issued a report to the Congress entitled, "Clean Water," which outlined some of the measures EPA is taking to implement the objectives of the 1972 amendments. EPA stated that processes-and-effects research, together with control technology, will be important elements in its water quality control program and that attention should be directed toward researching

--the effects of water pollution to develop criteria to be used in setting water quality standards for fresh and marine waters;

--health effects to develop water quality standards for drinking and recreational waters; and

--the effects and methods of controlling thermal discharges.

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A significant amount of processes-and-effects research is needed if EPA is to meet requirements of the Federal Water Pollution Control Act Amendments of 1972.

EPA's research on the effects of pollutants on freshwater life has provided some sound scientific data for developing water quality criteria. However, important research needs identified by the National Academy of Sciences remain to be satisfied and major EPA objectives remain to be met. Similarly, research data needed to support sound water quality standards in marine waters is either incomplete or nonexistent.

Available scientific data was inadequate for developing ocean-dumping criteria required by the act. As a result, the criteria developed was not always based on proven research results.

Research on thermal discharges has been delayed because of limited funding. Much of the laboratory research lacks the field verification needed to (1) establish sound water quality standards, (2) select sites for power plants and waste water cooling methods, (3) initiate enforcement actions, and (4) issue discharge permits.

The 1972 act authorized $300 million in grants to the States, for fiscal years 1973-75, to help them carry out approved nutrient control and restoration projects on lakes. However, EPA's lake survey will not be completed until 1976, and evaluating research for such projects will not, under current funding levels, be completed until 1979 or later.

Until EPA completes its lake survey and demonstrates the feasibility of nutrient control techniques, it will not have complete information

--to identify many lakes nationwide that might respond to nutrient control measures and

--to fully evaluate the probability of success of nutrient control techniques that States requesting grants under the lake restoration program might propose.

As EPA completes its lake survey and begins to demonstrate feasible nutrient control methods, it should establish a sound basis for awarding lake restoration grants to States, to insure the most effective use of its resources.

Some researchers believe that processes-and-effects research will be a never-ending effort because of the introduction each year of hundreds of new potential pollutants (such as synthetic chemicals), the complex nature of water pollution, and the limited amount of funds available to support research programs.

We believe it is important that, over the next several years, EPA's processes-and-effects research be directed toward obtaining the scientific knowledge needed to achieve the Nation's water pollution control goals and to implement EPA's policies as outlined in its Water Strategy Paper. This research should be coordinated with the development of effluent limitations based on advances made in water pollution control technology. As EPA develops and uses sound effluent limitations in its regulatory activities, the need for some processes-and-effects research may diminish.

CHAPTER 4

USE OF RESEARCH RESULTS BY EPA REGIONAL OFFICES, STATES, AND OTHERS

Generally, research results are made available to potential users in two ways; direct distribution through reports, articles, and papers and indirect distribution through national water quality criteria that are ultimately distributed to EPA and State users involved in establishing water quality standards.

Our analysis of selected Federal research projects showed that (1) about half of 204 completed projects did not have published research reports, (2) numerous communication and distribution problems limited direct use of research results, and (3) some research results were not incorporated into EPA's recently revised national water quality criteria. In addition, the revised water quality criteria were not available in time for EPA and State agencies to use them in developing water quality standards required by the Federal Water Pollution Control Act Amendments of 1972.

DELAYS IN PUBLISHING RESEARCH RESULTS

The following schedule shows the number of reports published as of December 1972 for the 204 research projects completed during fiscal years 1969-72.

Research area	Reports published	No reports published	Total
Marine fate	15	2	17
Marine effects	4	36	40
Lakes	13	22	35
Freshwater effects	30	48	78
Thermal fate	30	4	34
Total	92	112	204

The National Academy of Sciences, in developing water quality criteria on behalf of EPA, used data from many of the projects for which reports were not published. For example, in 1971, the Duluth laboratory completed a research project to determine the safe levels of copper and cadmium for egg and fry of several species of fish. Research results from this project were cited in the Academy's July 1972 draft Water Quality Criteria. As of June 1973, no report had been published on this project, although one is planned.

Research results may be informally released before publication. The chief of one of EPA's research field stations informed us, however, that many researchers, including himself, were reluctant to make research results known before publishing a report because other researchers might "steal" their findings and publish the results themselves. Our consultants said verbal research information had questionable value and it was preferable to have such information published and available for review by the scientific community.

Delays in publishing reports resulted from a lack of funds. According to the eutrophication research program director, delays were also caused by a change in EPA's funding procedures for publication costs. In fiscal year 1973, EPA required each research program to fund the cost of publishing its final report, although the approved research work plans for that year did not include allowances for publication.

On October 17, 1972, EPA headquarters asked the eutrophication program director to indicate how the costs to publish at least 11 reports would be met. The director recommended that he be authorized to reprogram $20,700 from an approved research task to publish the reports. He was informed in January 1973 that these funds were not available for publishing reports.

As of January 1973, publication of at least two final reports was being delayed while headquarters determined whether additional funds could be obtained. The program director told us that all program funds were committed and nothing was left for publishing reports. He said that, if funds were not obtained, no reports would be published during fiscal year 1973 and that this would mean that some reports could be delayed a year or more.

EPA's freshwater effects program had similar problems in getting its reports published. As of November 1972, the publication of reports for six extramural projects, which were funded at $428,000, had been delayed for 3 to 11 months. According to the program director, these delays occurred because headquarters officials would not transfer $5,150 from one category to another to fund the publishing.

Agency comments

In commenting on our draft report in a letter dated October 17, 1973 (see vol. I, pp. 95 to 99), EPA stated that:

> "To correct this situation, advance recognition is to be made of the cost of publication of final reports, and funding/reprogramming procedures have been made almost automatic. In addition, the status of the publication of reports will be monitored as part of OR&D's over-all management information system to assure timely publication."

LIMITED USE OF RESEARCH RESULTS BY FEDERAL AND STATE AGENCIES

Direct use of EPA's research reports was limited because of problems in communicating, marketing, and implementing research results in each of the programs reviewed. We provided selected EPA research reports to officials of EPA regional offices, State agencies, and various private firms, including consulting firms that were under contract to State water pollution control agencies, and discussed their use of the research results. We obtained information on their awareness and use of the selected reports, together with their views on potential uses. The results of these discussions are shown in appendix II.

Research results were often not used because potential users either

--were unaware of them,

--could not apply them under field conditions or at other sites,

- --could not understand some research reports which, in their opinion, were written for researchers and were not sure how the results should be applied, or

- --expressed doubt as to their validity or reliability.

Another factor limiting the use of research results was the publishing method the Duluth laboratory used for its inhouse research results. This research was not published in EPA's Water Pollution Control Research Series, which was intended to provide a central source of information on EPA's research activities. Instead, the research results were published in various scientific journals with a circulation of several thousand. The laboratory director said scientific journals are a permanent record, whereas Government publications are exceedingly difficult to get a few years after they are issued.

We agree that scientific journals are a good permanent record, but we believe that research results should also be published in EPA's Water Pollution Control Research Series since this is the central source of information on EPA's research activities.

The laboratory distributed reprints of reports published in journals to about 400 agencies and individuals. However, only six State pollution control agencies were on the laboratory's distribution list. The laboratory director informed us that reprints are distributed to State agencies when specifically requested. However, State water pollution control agencies have continuing responsibilities to set and enforce water quality standards. Therefore, it should not be left to chance as to whether such agencies are aware of research results concerning water quality.

In our opinion, processes-and-effects research results should be:

- --Evaluated to identify specific activities, locations, or organizations to which the results can or should be distributed.

- --Converted to an understandable and readily usable form, such as user manuals and computer programs.

- --Marketed through educational seminars and meetings where researchers can demonstrate specific applications.

USE OF EPA RESEARCH RESULTS TO DEVELOP WATER QUALITY CRITERIA

Research on the effects of pollutants on freshwater and marine fish and other aquatic life has been directed toward developing valid criteria for setting water quality standards. However, many of EPA's research results were not used in developing new national water quality criteria for fresh and marine waters.

In 1967, the Secretary of the Interior established the National Technical Advisory Committee on Water Quality Criteria. The National Technical Advisory Committee Report "Water Quality Criteria," published in 1968 and often referred to as the "green book," provided the basis for developing water quality standards for interstate and coastal waters.

In 1971, EPA stated that new scientific knowledge on water quality requirements and tolerances had been acquired since 1968.

In fiscal year 1973, EPA budgeted funds to upgrade and expand the green book to establish criteria for navigable waters[1] as required by the then-pending amendments to the Federal Water Pollution Control Act.

To do this, it contracted with the National Academy of Sciences to prepare a new report on water quality criteria. EPA agreed to provide the Academy with scientific data from its in-house and extramural research and with reports of literature searches underway. The Academy was responsible for obtaining additional information needed to fill gaps in scientific knowledge.

We reviewed a draft of the Academy's July 1972 water quality criteria and we analyzed the extent the Academy used

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[1] As defined by EPA and the Federal Water Pollution Control Act Amendments of 1972, all waters of the United States, including interstate and intrastate waters.

EPA's research results in developing criteria for fresh and marine waters. The criteria cited some of EPA's complete and on-going research efforts.

During fiscal years 1969-72, EPA completed 78 major projects and published 30 final research reports on the effects of pollutants on freshwater life. As of June 30, 1972, 51 projects were in progress. The Academy's water quality criteria cited results of 33 of the completed or active research projects. For example, in the area of freshwater effects, 10 EPA in-house research projects to develop dissolved oxygen requirements had been completed or terminated, but only 1 was cited by the Academy in developing criteria for dissolved oxygen. Similarly, the Academy used only 12 of EPA's 470 papers on the effects of pollutants on marine life.

The Academy panel members informed us that some of EPA's processes-and-effects research was not used because: (1) some of the results did not apply directly to the criteria and (2) the panel believed that scientific information from other sources was more directly related to establishing water criteria.

REVISED WATER QUALITY CRITERIA NOT AVAILABLE WHEN NEEDED

Because of delays in updating existing water quality criteria to incorporate new scientific data obtained from research, the revised criteria were not available to implement legislative requirements for setting water quality standards. Instead, criteria published in 1968, now acknowledged to be outdated and incomplete, provided the basis for establishing State water quality standards in 1973.

EPA informed the Congress in April 1971 that the 1968 criteria had to be updated to meet the requirements for setting water standards contained in proposed amendments to the Federal Water Pollution Control Act. The amendments were enacted in October 1972, including section 303 concerning water quality standards.

The timetable to adopt revisions to exisiting interstate and intrastate standards and new intrastate standards as required by the amendments was as follows:

Existing interstate standards--April 18, 1973
Existing intrastate standards--June 18, 1973
New intrastate standards--October 18, 1973

The amendments also require the States to review their water quality standards at least every 3 years and modify them or adopt new standards as appropriate.

EPA's contract with the Academy called for a draft report on water quality criteria for EPA's unrestricted use and distribution by December 1971, with a final report planned by May 1972. The Academy submitted an initial draft to EPA in December 1971. Due to EPA's delays in approving the report, the final draft report was not available until July 1972. EPA officials informed us that the draft was delayed for about 6 months while they waited for other agencies to review it. The officials advised us that the final report was approved for publication in February 1973 and that it should be published and distributed by December 1973.

The Academy, in its draft report, pointed out that it did more than just revise the 1968 criteria. Its new criteria was nearly four times longer and discussed many new subjects in detail, i.e., toxic or potentially toxic substances not included in the green book. The draft report also expanded data available from recent research activities and showed greater awareness of how various characteristics of water affect its quality and use.

In November 1972, EPA informed its regional administrators that reviewing and revising water quality standards would be a priority task in implementing the 1972 amendments and that, as a matter of policy, the 1968 water quality criteria should be used in reviewing and revising the standards.

Updating existing water quality criteria is a long, time-consuming task and, in our opinion, should be done on a more frequent basis. Instead of revising the criteria every 5 years or so, revisions should be considered as new valid research results become available, so that new scientific data can be transferred to potential users faster. Such a method, for example, could entail the publication and maintenance of a criteria manual where changes due to expanded, revised, or deleted criteria can be made by simply replacing pages.

CHAPTER 5

COORDINATION WITH OTHER FEDERAL AGENCIES

Coordination between EPA and other Federal agencies needs to be improved because EPA was not aware of research efforts on lake eutrophication and marine waters funded by the Departments of Commerce and the Interior, AEC, and NSF.

MARINE EFFECTS RESEARCH

EPA's laboratory at West Kingston and the Department of Commerce National Marine Fisheries Service Laboratory at Milford conducted research programs concerned with the effects of pollutants on marine organisms. During fiscal years 1971-73, the West Kingston laboratory funded about $9 million; the Milford laboratory funded about $2 million during fiscal years 1971-72.

The laboratories did not adequately coordinate their plans and, as a result, certain programs were similar or duplicative. For example, both laboratories were (1) researching the effects and tolerances of heavy metal contaminants on marine resources, food chain organisms, and the marine animal environment, (2) studying the ecological requirements for temperature, oxygen, and salinity, and (3) developing bioassay (biological) techniques and studying the physiological responses of fish. Both laboratories researched or were planning to research the effects of such metals as cadmium, chromium, copper, lead, mercury, nickel, and zinc on the same species of mollusks, crustaceans, finfishes, plants, and algae.

The following tables show that the laboratories were researching many of the same metals and marine species.

Metals Studied or to be Studied

West Kingston	Milford
Cadmium, calcium, chromium, copper, iron, lead, magnesium, mercury, nickel, strontium, zinc.	Arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, zinc.

Marine Species Studied or Planned for Study by Both Laboratories

Crustaceans:
- [a]Blue crab
- Cancer crab
- Lobster

Finfish:
- Blue fish
- Yellow flounder
- [a]Striped bass
- Cod
- Spot
- Shad
- Sea bass
- Mullet
- Winter flounder
- Menhaden
- White perch

Mollusks:
- [a]Oyster
- [a]Soft-shell clam
- [a]Mud snail
- Bay scallop
- [a]Hard clam
- Squid
- Blue mussel
- Mahogany clam
- [a]Quahogs

[a] Studies already made by both laboratories.

In 1971 agency headquarters officials held meetings to discuss the research activities of the two laboratories. In May 1971, EPA informed the Department of Commerce that their respective staffs had examined the activities of the two laboratories and concluded that no current or planned research was duplicative. EPA pointed out that pollution problems in the marine environment are so great that coordinated efforts are highly desirable. EPA also said it would take continuous action to insure that programs were not duplicative but coordinated.

Neither agency, however, established mechanisms or procedures for coordinating the research programs of the two laboratories. We showed each laboratory director the research plans and programs being carried out by the other laboratory. Both directors stated that their plans overlapped significantly. Agency officials again agreed to coordinate the laboratories' work.

Agency actions

The Department of Commerce in a letter to us dated October 26, 1973, stated that

> "Most recently the laboratory Directors and principal investigators of Milford and West

Kingston met to discuss the research activities of the two laboratories. A mechanism was established for better coordination of the research programs of the laboratories. It was agreed that periodic meetings would be made to ensure that the programs remain non-duplicative, but complementary."

LAKES RESEARCH

EPA and four other Federal agencies funded about $13.7 million on research and demonstration projects related to eutrophication and lake restoration during fiscal years 1969-72, as the following table indicates.

	Fiscal years				
	1969	1970	1971	1972	Total
	(000 omitted)				
EPA	$1,739	$1,349	$2,880	$2,101	$ 8,069
AEC	273	262	280	152	967
The Interior--Office of Water Resources Research	724	834	823	748	3,129
NSF	155	110	285	162	712
Commerce	200	200	200	211	811
Total	$3,091	$2,755	$4,468	$3,374	$13,688

EPA and the other agencies did not effectively coordinate their efforts. EPA did not advise other agency officials of the nature and extent of its research program nor of projects being funded under the program. The other agencies seldom asked EPA program officials to review the research proposals they received and did not advise EPA of the research they were doing.

The Office of Water Resources Research and AEC officials said they were not aware that EPA was doing much research relating to eutrophication and lake restoration and were not familiar with projects being funded by EPA. They said they assumed their grantees kept abreast of all related projects through research literature and informal contacts with other investigators to avoid duplicating work.

The Office of Water Resources Research sent proposals for only 15 percent of its 156 projects relating to eutrophication to EPA for review during fiscal years 1969-72. An NSF official said he recalled discussing only 3 or 4 of NSF's 11 projects informally with EPA officials, and AEC officials said they did not contact EPA concerning any of their 8 projects.

At our request, an EPA program official reviewed copies of research summaries for 70 Office of Water Resources Research projects, 9 NSF projects, and 6 AEC projects relating to eutrophication and lake restoration. He said he was aware of only a few of these projects and about 80 percent of them dealt with topics of concern to his program. He said it would be valuable for his program personnel to review and comment on proposals if project results were furnished to EPA, because it would reduce the potential for duplicating other agencies' research.

Two related projects--one funded by EPA and the other funded by AEC--were conducted by the same principal investigator at the same time. Officials of both agencies said there was no interagency contact on these projects and they were not aware of each other's interest in the research. Although no significant duplication was noted, the content and timing of the final reports depended, to some extent, on the conduct of both projects. The principal investigator told us that his AEC project would have been more appropriate for EPA to fund but that he did not seek EPA funding for both projects because funds appeared to be restricted at the time.

CHAPTER 6

PROBLEMS WITH EPA'S PLANNING SYSTEM AND MONITORING OF PROJECTS

PLANNING

EPA's planning system is objective-oriented; each specific research plan includes all tasks that must be completed to reach a defined objective by a certain date. With this system, EPA can compare the various plans to reach decisions on funding.

EPA's fiscal year 1973 research plans on the fate of pollutants in marine waters were written for general areas of research, involving many tasks not always related to a single problem or specific solution. For example, the research plan for developing scientific criteria for ocean disposal described several research objectives, including (1) determining the maximum permissible levels of an unlimited number of marine pollutants, (2) determining the maximum effluent concentrations for various marine discharges, and (3) identifying acceptable discharge sites for allowable materials. However, the plan did not lay out separate or complete research approaches, timetables, and the estimated funding necessary to solve each of these problems. As a result, EPA management did not have an adequate basis to make a full-funding or no-funding decision for several research efforts directed toward solving specific problems. In this case, EPA approved the general research plan with funding at about 30 percent of the level initially requested. As a result, two major new extramural research projects related to ocean-dumping criteria were deferred for at least a year.

MONITORING EXTRAMURAL RESEARCH PROJECTS

During our review, we noted that the research projects on the effects of pollutants on freshwater life needed to be monitored better. In several cases, there was almost no communication between EPA project officers and research grantees on objectives or direction of effort. Some contacts with researchers occurred annually when project officers reviewed proposals for renewing the research grants. EPA's limited knowledge on the status and results of projects can lead to questionable funding of research projects. Project officers informed us that grants for research projects that were producing meager or poor quality results were renewed because substantial amounts of funds had already been invested in the projects.

For example, EPA funded a 3-year project during fiscal years 1970-72 to determine the effects of temperature, copper, and zinc on the locomotion of fish. The estimated cost was $200,000. During this 3-year period, EPA's project officer did not visit the research site to obtain firsthand information on the progress of the research nor did he discuss job direction or objectives with the principal investigator except during his annual review of proposals to renew the research grant.

After 9 months, the project officer recommended renewing the grant because, in his opinion, the project was excellent and had no weaknesses. A year later, however, the project officer's opinion had changed. He had reviewed a paper describing the work accomplished and concluded that (1) the description of the experimental and statistical procedures was very thin and ambiguous, (2) terminology seemed too loose, and (3) the experimental design seemed inadequate. EPA reviewers believed the paper's conclusions were not scientifically sound because they were based on a sample of only seven goldfish.

The project officer recommended renewing the grant for a third year if the project were modified, because substantial funds had already been invested. Modifications would include (1) exposing more fish for longer periods of time, (2) checking all possible test variables, and (3) conditioning fish to the test tank several days before testing. The researcher was informed of these modifications in May 1971 before starting his third year of research. The project officer informed us in January 1973 that he did not contact the researcher during the last year of the project to determine whether the modifications were made.

On November 21, 1972, we issued a report to the Congress entitled, "Need to Improve Administration of the Water Pollution Research, Development and Demonstration Program," (B-166506). In the report we stated that, in many cases, EPA had inadequately monitored ongoing research projects because progress reports had not been submitted or had been submitted late and project officers had not visited project sites. We recommended that the Administrator require project officers to promptly contact grantees and contractors to urge them to submit progress reports and final reports on time. As of October 1973, EPA was taking action on our recommendation.

LEGISLATIVE PROVISIONS FOR

PROCESSES-AND-EFFECTS RESEARCH

Several sections of the Federal Water Pollution Control Act Amendments of 1972 require or authorize the Administrator, EPA, to conduct processes-and-effects research as follows.

SECTION 104

Section 104 provides that the Administrator establish national programs for preventing, reducing, and eliminating pollution, and, as part of such programs

--conduct research relating to the causes, effects, and extent of pollution;

--collect and disseminate basic data on the chemical, physical, and biological effects of varying water quality, and other information on pollution;

--conduct in cooperation with others, public investigations concerning the pollution of any navigable waters and report on the results of such investigations;

--collect and make available, through publications and other means, the results and other information, including recommendations by him of such research and other activities relating to the causes, effects, and extent of pollution;

--develop effective practical processes, methods, and prototype devices to prevent, reduce, and eliminate pollution;

--conduct, in cooperation with the Department of Health, Education, and Welfare, research on, and survey the results of, the harmful effects of pollution on the health and welfare of persons;

--conduct research and technical development work and make studies on the quality of the waters of the Great Lakes;

- --develop and demonstrate, under varied conditions, improved methods and procedures for identifying and measuring the effects of pollutants, including those pollutants created by new technological developments;
- --enter into contracts and make grants to develop and demonstrate new or improved methods for the prevention, removal, reduction, and elimination of pollution in lakes, including the undesirable effects of nutrients and vegetation;
- --develop and issue the latest scientific knowledge available in indicating the kind and extent of expected effects from the presence of varying quantities of pesticides in the water on health and welfare;
- --conduct studies and investigations of methods and alternatives to control the release of pesticides into the environment, including the examination of the persistency of pesticides in the water environment;
- --conduct, promote, and encourage, in cooperation with others, contributions to continuing comprehensive studies of the effects of pollution, including sedimentation, in the estuaries and estuarine zones of the United States on fish and wildlife, sport and commercial fishing, recreation, water supply and water power, and other beneficial purposes;
- --assemble, coordinate, and organize all existing pertinent information on the Nation's estuaries and estuarine zones, carry out a program of investigations and surveys to supplement existing information in representative estuaries and estuarine zones, and identify the problems and areas where further research and study are required;
- --carry out in cooperation with others a comprehensive study and research program to determine new and improved methods and better application of existing methods for preventing, reducing, and eliminating pollution from agriculture, including the legal, economic, and other implications of using such methods;

- make grants to colleges and universities to conduct basic research into the structure and functions of fresh water aquatic ecosystems, and to improve understanding of the ecological characteristics necessary to maintain the chemical, physical, and biological integrity of freshwater aquatic ecosystems;

- make grants to educational institutions which are regionally located and will be designated as "River Study Centers," to conduct and report interdisciplinary studies on the nature of river systems, including hydrology, biology, ecology, economics, and the relationship between river uses and land uses and the effects of development within river basins on river systems and on the value of water resources and water-related activities; and

- conduct comprehensive studies, in cooperation with others, on the effects and methods of controlling thermal discharges.

To carry out the above provisions, the act authorized $135 million to be appropriated per fiscal years 1973 and 1974.

SECTION 105

Section 105 directs the Administrator to conduct an acceleration effort to develop, refine, and achieve practical application of improved methods and procedures to identify and measure the effects of pollutants on the chemical, physical, and biological integrity of water, including those pollutants created by new technological development.

SECTION 114

Section 114 provides that the Administrator, in cooperation with others, research the adequacy of the need for extending Federal oversight and control to preserve the fragile ecology of Lake Tahoe. To carry out this section, the act authorized $500,000 to be appropriated.

SECTION 115

Section 115 directs the Administrator to identify the location of in-place pollutants with emphasis on toxic pollutants in harbors and navigable waterways; acting through the

Secretary of the Army, the Administrator is authorized to make contracts for removing and disposing of such materials. The act authorized $15 million to be appropriated to carry out the provisions of this section.

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Several sections of the act require that EPA establish standards and guidelines based on water quality criteria developed through processes-and-effects research.

SECTION 303

Section 303 requires the States to establish and review, at least every 3 years, standards, based on water quality criteria, subject to EPA approval for interstate and intrastate waters.

SECTION 304

Section 304 requires the Administrator to develop and publish water quality criteria which accurately reflect the latest scientific knowledge. He also must develop and publish information on the (1) factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters, (2) factors necessary to propagate shellfish, fish, and wildlife and to allow recreation in or on the water, (3) measurement and classification of water quality, and (4) identification of pollutants suitable for maximum daily load measurement correlated with achieving water quality objectives.

SECTION 307

Section 307 requires the Administrator to publish a list which includes toxic pollutants for which the Administrator must establish effluent standards. The Administrator must take into account the pollutants' toxicity, persistence, and degradability and the usual or potential presence of affected organisms and the nature and extent of the effect of toxic pollutants on them.

SECTION 314

Section 314 requires the State to prepare and submit to the Administrator for his approval (1) an identification and classification, according to eutrophic condition, of all publicly owned freshwater lakes, (2) procedures, processes, and methods to control sources of pollution in such lakes, and (3) in conjunction with appropriate Federal agencies, methods and procedures to restore the quality of such lakes.

The 1972 amendments authorize appropriations of $300 million during fiscal years 1973-75 for grants to assist the States in carrying out pollution control and restoration programs on lakes.

SECTION 403

Section 403 provides that the Administrator set guidelines for determining the degradation of territorial seas, contiguous zones, and oceans, which shall include

--the effect of pollutant disposal on human health or welfare, including but not limited to plankton, fish, shellfish, wildlife, shorelines, and beaches;

--the effect of pollutant disposal on marine life, including the transfer, concentration, and dispersal of pollutants or their byproducts through biological, physical, and chemical processes; changes in marine ecosystem diversity, productivity, and stability; and species and community population changes;

--the effect of pollutant disposal on esthetic, recreational, and economic values;

--the persistence and permanence of the effects of pollutant disposal;

--the effect of the disposal of particular volumes and concentrations of pollutants at varying rates;

--other possible locations and methods for disposing of recycling pollutants, including land-based alternatives; and

--the effect on alternate uses of the oceans, such as mineral exploitation and scientific study.

USE OF RESEARCH REPORTS

Table I

Use of Six EPA Research Reports on the Fate of Pollution in Marine Waters

Organizations visited	Number of reports aware of	Used for: General information	Used for: Evaluating discharge sites	Potential uses: General information	Potential uses: Evaluating discharge sites
EPA:					
Region I	4	-	2	2	-
Region IX	6	-	2	2	1
Region X	6	-	3	1	1
State water pollution control agencies:					
California	5	-	-	3	1
Connecticut	-	-	-	2	-
Florida	1	-	1	-	-
Maine	-	-	-	-	-
Massachusetts	1	-	1	-	-
New York	1	-	1	-	-
Washington	4	-	1	3	-
Private firms:					
Water Resources Engineering, Inc.	1	-	-	1	-
Quirt, Lowbar, Matusky, Tamppen	3	1	1	-	-
Hydro Sciences, Inc.	2	-	-	1	-
Malcolm Pirnie, Inc.	6	-	-	-	-

USE OF RESEARCH REPORTS

Table II

Use of Seven EPA Research Reports on the Effects of Pollutants on Freshwater Life (note a)

		Used for			Potential uses		
Organizations visited	Number of reports aware of	General information	Standards or enforcement	Impact statements	General information	Standards or enforcement	Impact statements
EPA:							
Region II	1	-	-	-	-	-	1
Region III	4	-	-	-	-	3	-
Region V	3	-	3	-	-	1	-
Region IX	3	-	-	-	2	3	-
Region X	7	1	-	3	-	3	-
State water pollution control agencies:							
Minnesota	1	-	-	-	-	-	-
New York	2	-	-	-	-	-	-
Oregon	1	-	-	-	-	-	-
Pennsylvania	3	-	-	-	-	-	-
Washington	3	-	-	-	1	-	-

[a] All research reports actually used for purposes other than background information were the results of one research project the research director identified as highly successful.

USE OF RESEARCH REPORTS

Table III

Use of Six EPA Research Reports on the Effects of Pollutants on Marine Life

Organizations visited	Number of reports aware of	Used	Potentially useful
EPA:			
Region I	1	-	6
Region IX	3	-	4
State water pollution control agencies:			
California	3	-	2
Connecticut	-	-	1
Florida	2	-	4
Maine	-	-	1
Massachusetts	1	-	-
New York	-	-	1

USE OF RESEARCH REPORTS

Table IV

Use of Five EPA Research Reports on Eutrophication

Organizations visited	Number of reports aware of	Used for		Potential uses	
		General information	Monitoring	General information	Monitoring
EPA:					
Region I	5	-	-	(a)	(a)
Region IX	5	-	1	(a)	(a)
Region X	5	1	1	(a)	(a)
State water pollution control agenices:					
Florida	3	2	1	-	-
Maine	4	-	-	1	1
Massachusetts	2	-	-	(a)	(a)
Michigan	4	2	1	(a)	(a)
Minnesota	3	1	-	1	-
New Hampshire	4	1	-	1	1
New York	2	1	-	-	1
Wisconsin	3	1	-	1	1

[a] Opinion on potential usefulness not given.

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USE OF RESEARCH REPORTS

Table V

Use of 11 EPA Research Reports on the Fate of Thermal Pollution

Organizations visited	Number of reports aware of	Used for: General information	Used for: Site selection	Potential uses: General information	Potential uses: Effluent standards	Potential uses: Defining mixing zones
EPA:						
Region II	7	3	-	-	-	-
Region IV	11	11	-	-	-	-
Region V	11	5	-	-	-	-
Region X	11	-	-	-	-	-
State water pollution control agencies:						
Ohio	3	1	1	-	8	-
Michigan	11	1	-	-	-	-
Florida	-	-	-	-	-	-
Washington	-	-	-	-	-	-
Oregon	-	-	-	-	-	-
Minnesota	11	11	-	-	-	-
Tennessee	11	-	-	-	11	-
Georgia	11	-	-	-	-	-
Wisconsin	11	11	-	-	-	[a]1
New York	7	-	-	-	-	-
Private firms:						
Burns & Roe, Inc.	1	1	-	7	3	-
New York Power Pool	-	-	-	11	-	-
Consolidated Edison Co. of New York, Inc.	2	-	-	-	-	-
Texas Instruments, Inc.	-	-	-	1	-	-
Edison Electric Institute	1	-	-	-	-	-
American Electric Power Service Corp.	3	1	-	4	-	-

[a] One of the 11 reports used for general information.

USE OF RESEARCH REPORTS

Table VI

Use of 10 EPA Research Reports on the Effects of Thermal Pollution

Organizations visited	Number of reports aware of	Used for		Potential uses	
		General information	Effluent standards	General information	Water quality standards
EPA:					
Region IV	-	-	-	-	10
Region X	-	-	-	-	-
State water pollution control agencies:					
Wisconsin	4	-	-	-	-
Georgia	10	-	-	-	-
Tennessee	-	-	-	-	-
Minnesota	10	-	1	-	-
Oregon	-	-	-	-	4
Washington	-	-	-	-	-
Ohio	10	10	-	-	-

UNITED STATES GENERAL ACCOUNTING OFFICE

REPORT TO THE CONGRESS

Research And Demonstration Programs To Achieve Water Quality Goals: What The Federal Government Needs To Do

B-166506

ENCLOSURE B

Technology Development Programs
For Solving Municipal Waste Water
Treatment Problems

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

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GLOSSARY

Biochemical oxygen demand	A measure of the oxygen consumed in the biological processes that break down organic matter in water. Large quantities of organic wastes require large amounts of dissolved oxygen. The more oxygen demanding matter, the greater the pollution.
Chemical oxygen demand	A measure of the oxygen required to oxidize organic and oxidizable inorganic compounds in water. It is an indicator of the degree of pollution.
Combined sewers	Carry both sanitary sewage and storm water runoff. During dry weather, combined sewers usually carry all the waste water to the treatment plant. During a storm, only part of the mixed flow is carried to the plant due to overloading; the rest is discharged, untreated, into waterways.
Denitrification	The process of taking nitrogen out of matter.
Eutrophication	The process whereby a lake becomes overfertilized from too many nutrients, especially phosphorus and nitrogen. As a result, algae and other plant life become overabundant, and the lake may evolve into marshland.

Infiltration	Occurs when water enters sewers and sewer connections through defective joints, broken or cracked pipe, improper connections, and manhole walls.
Nitrification	The process of combining matter with nitrogen or a nitrogen compound.
Nutrients	Elements or compounds essential as raw materials for organism growth and development; e.g., carbon, oxygen, nitrogen, and phosphorus.
Physical-chemical treatment	Includes processes such as chemical clarification, filtration, and disinfection. These processes may be a tertiary stage after biological secondary treatment or may replace biological treatment.
Primary treatment	The first stage in waste water treatment which uses screening and sedimentation techniques to remove about 30 percent of the biochemical oxygen-demanding wastes.
Secondary treatment	Using biological processes to accelerate the decomposition of sewage. Efficient treatment will reduce the biochemical oxygen demand in waste water by 80 to 90 percent.
Sludge	The solid matter removed from waste water through treatment. Sludge handling involves the processes that remove solids and make them ready for disposal. Disposal may involve

	incineration, dumping in waterways, or land application.
Stabilization ponds	Manmade impoundments that hold waste water. The holding process permits solids to settle out and biological decomposition to occur.
Tertiary or advanced treatment	Involves processes beyond secondary treatment that will further reduce the biochemical oxygen demand or remove a higher percentage of specific pollutants. It is a more complex procedure than secondary treatment and may include chemical treatment, electrochemical processing, or carbon filtration.

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ABBREVIATIONS

ARS	Agricultural Research Service, Department of Agriculture
BOD	biochemical oxygen demand
COD	chemical oxygen demand
EPA	Environmental Protection Agency
EXPRO	Extramural Program Information Bulletin
NERC	National Environmental Research Center
OR&D	Office of Research and Development
OWP	Office of Water Programs
R&D	research, pilot, development, and demonstration

CHAPTER 1

INTRODUCTION

This enclosure includes the results of our study of technology development programs for solving municipal waste water treatment problems. States and municipalities have relied on the Federal Government to conduct research, pilot, development, and demonstration (R&D) programs to help them meet Federal and State requirements for water pollution control. The Environmental Protection Agency (EPA)[1] has conducted most Federal R&D on municipal water pollution problems.

During fiscal years 1966-73, EPA's Municipal Pollution Control Division, Office of Research and Development (OR&D),[2] spent about $140 million to develop technology for municipal water pollution control. (See app. I.) The Department of Agriculture has spent $2.9 million for municipal water pollution research since 1967; the Corps of Engineers $0.9 million in fiscal years 1972 and 1973; and the Department of Housing and Urban Development $2.6 million for fiscal years 1969-73.

MUNICIPAL WASTE DISCHARGES: A SIGNIFICANT SOURCE OF WATER POLLUTION

In 1968 EPA estimated that over 120 million pounds of biochemical oxygen demand (BOD) wastes were produced daily, of which 45 to 50 million pounds were discharged into the Nation's waterways. About 35 percent of the BOD wastes were discharged from municipalities.

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[1] EPA and its predecessor agencies. See app. III, vol. 1.

[2] In June 1973, EPA reorganized its R&D activities and the Municipal Technology Branch became the Municipal Pollution Control Division under the Deputy Assistant Administrator for Environmental Engineering, OR&D.

Waste loads entering municipal sewage systems are expected to increase nearly four times in the next 50 years as a result of increasing populations and the continued movement of rural population to urban areas. For example, 66 percent of the 1960 population was located in metropolitan areas with over 100,000 people, whereas 71 percent was so located by 1970. This is expected to increase to 85 percent by the year 2000.

The map on page 3 shows the relative pollution index, by drainage area, of waters in the United States together with the locations of 212 urban centers with populations of more than 75,000. The map shows that most large urban centers are located in the more polluted drainage areas.

EPA, in a 1971 report, identified the following prime sources of man-caused pollution for many of the Nation's waterways.

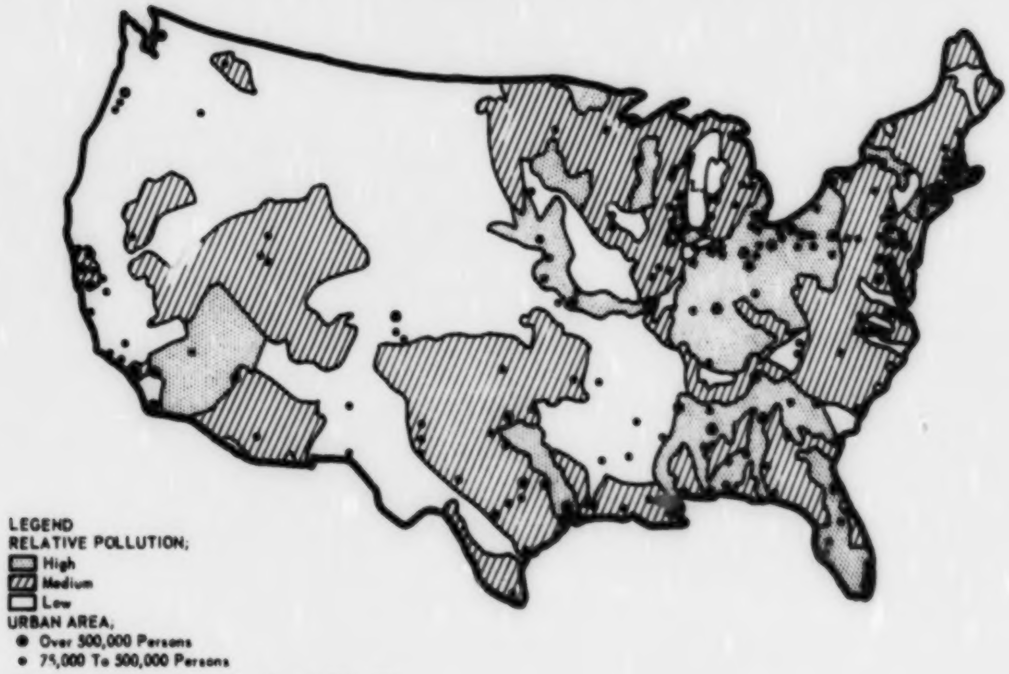
	Percent
Industrial discharges	23.7
Municipal waste water and other urban discharges	21.8
Agriculture and mining	14.0
Other	5.1
Total	[a]64.6

[a]Natural causes account for the remaining 35.4 percent.

MUNICIPAL PROGRESS IN CONTROLLING WATER POLLUTION

Pursuant to the Water Quality Act of 1965 (Public Law 89-234), States established water quality standards and pollution abatement plans to achieve the standards. The plans usually required municipalities to construct facilities to provide secondary treatment of their dry-weather waste flows but did not usually require them to construct facilities to treat combined sewer discharges. The plans included (1) constructing new treatment plants, (2) expanding existing plants, (3) upgrading treatment from primary to secondary, and (4) adding facilities to achieve a high rate of removal of a specific pollutant. Many municipalities planned to treat wastes from industries within their jurisdiction.

RELATIVE POLLUTION INDEX BY DRAINAGE AREA, AND THE LOCATIONS OF METROPOLITAN AREAS (OVER 75,000 POPULATION)


LEGEND
RELATIVE POLLUTION;
▨ High
▨ Medium
☐ Low
URBAN AREA,
● Over 500,000 Persons
• 75,000 To 500,000 Persons

SOURCE: "The Economics of Clean Water," EPA, 1972

Progress made in treating or improving treatment of wastes from the population served by sewers from 1968 to 1972 is indicated by the EPA estimates below.

	Fiscal year				
	1968	1969	1970	1971	1972
Population served by sewers (millions)	140	144	148	152	156
BOD wastes treated by municipal plants (billion of pounds)	14.1	14.8	15.4	16.1	16.9
Level of treatment (Percent of population served by sewers):					
Untreated	7	7	6	6	5
Primary	31	30	28	25	24
Secondary	62	63	66	68	70
Advanced	<1	<1	<1	<1	<2

Symbol < indicates "less than."

The data shows that the treatment of wastes is keeping pace with the increase in the population served by sewers.

COSTS OF MUNICIPAL WASTE TREATMENT CONTROL FACILITIES PLANNED FROM 1972 TO 1976

On the basis of a 1971 survey of about 2,200 municipalities with populations over 10,000, EPA estimated what it would cost municipalities to build the facilities planned for fiscal years 1972-76.

Fiscal year	Amount (billions)
1972	$ 5.3
1973-74	9.3
1975-76	3.5
Total	$18.1

These estimates, however, include only those facilities that the municipalities plan to build by 1976. Those planned may not necessarily be all those needed to control water pollution or fully meet the water quality standards. For example, municipalities generally did not plan to build facilities needed to control pollution from combined sewers, primarily because of the high cost of such facilities.

SCOPE OF REVIEW

We concentrated on EPA's program because EPA has done most of the Federal R&D to develop technology for municipal water pollution control. We reviewed program documents and held discussions with officials at EPA headquarters in Washington and at three EPA laboratories. We also visited selected project locations. We met with officials and reviewed data of the Department of Agriculture and the Corps of Engineers, Department of the Army, in those areas that related to technology for municipal water pollution control. We also met with officials of four State water pollution control agencies.

We sent questionnaires to 100 large municipalities (see app. II) to obtain their views on technology development programs for municipal water pollution problems. In addition, three consultants helped us evaluate the efficacy of Federal efforts in selected R&D areas.

We concentrated on the following municipal technology R&D areas.

- --Sludge handling and disposal.
- --Combined sewers and storm water discharges.
- --Nutrient removal--phosphorus and nitrogen.
- --Stabilization ponds.
- --Mercury in sediment.
- --Nonpolluting discharges.
- --Soil treatment systems.
- --Product control technology.

The above areas represent about $83 million, or 60 percent, of the $138 million used for EPA's municipal technology program for fiscal years 1966-72.

CHAPTER 2

FEDERAL R&D PROGRAMS TO DEVELOP MUNICIPAL POLLUTION CONTROL TECHNOLOGY

Few States and municipalities have R&D programs and therefore rely on the Federal Government, particularly EPA, to develop the technology to solve their water pollution problems. EPA's technology development program for controlling municipal water pollution has generally been concentrated on major problem areas, such as combined sewer discharges, sludge handling and disposal, and nutrient removal--areas of particular concern to municipalities. EPA research has not, however, resulted in major technological breakthroughs or broad application of R&D results--primarily because of the high cost of implementation. Funding for municipal technology development has decreased since 1967, while 1972 legislation has imposed more requirements on municipalities.

PROBLEMS, PROGRESS, AND TECHNOLOGY: MUNICIPALITIES' VIEWS

We sent questionnaires to 100 large municipalities to determine

--the major municipal and metropolitan water pollution control problems,

--the actions taken or planned to solve these problems,

--the problems they believe require R&D, and

--what Federal R&D priorities should be.

The 78 water pollution control organizations that responded serve about 64 million persons, or about 30 percent of the Nation's population, and accounted for 81 of the 100 municipalities to whom we sent questionnaires. The following sections summarize their responses.

Municipal water pollution control problems

Municipalities were asked to identify their most serious water pollution problems in 1967 and 1972 and those anticipated in 1980. Four of the most frequently cited problems for all 3 years and the percentage of municipalities citing the problems follow.

Problems (note a)	Percentage of municipalities 1967	1972	1980
1. Lack of or inadequate treatment facilities	86	82	58
2. Combined sewers and/or storm water discharges	59	59	58
3. Sludge handling and disposal	32	33	28
4. Nutrient removal	24	26	23

[a] Sewer infiltration and discharges from industries located within municipal boundaries were also mentioned frequently. Infiltration occurs mainly because of damaged or deteriorated collection sewers. Costs for collection sewers were not eligible for EPA construction grants before October 1972. Industrial discharges are discussed in enclosure C.

The percentage of municipalities listing each problem area is relatively constant for all 3 years, with the exception of area 1 where municipalities indicated that progress is anticipated in resolving this problem.

We asked the municipalities to rank 10 research areas being emphasized by EPA's Municipal Pollution Control Division in the order of priority they believed should exist. The consensus was:

1. Sludge disposal.
2. Advanced biological treatment processes.
3. Sludge handling and dewatering (removing water from sludge).
4. Combined sewer discharges.

5. Physical-chemical treatment processes.
6. Phosphorous and nitrogen removal processes.
7. Municipal treatment of industrial wastes.
8. Nonsewered and separate storm runoffs.
9. Soil treatment systems.
10. Upgrading efficiency of stabilization ponds.

Municipalities were also asked to identify those problem areas needing new or improved technology and to indicate the type of research required. Their responses were as follows.

1. Inadequate treatment facilities--research needed to reduce costs and improve secondary processes to use less energy.

2. Combined sewer and storm water discharges--research needed to reduce control costs.

3. Sludge handling and disposal--research needed to reduce costs, make process easier, reduce use of energy, and determine effects of disposal on land.

Factors contributing to or impeding municipal progress

Most municipalities stated that inadequate treatment facilities have decreased since 1967. They have achieved progress by expanding treatment facilities, constructing new facilities, and upgrading treatment. Most municipalities indicated that progress was made possible by factors other than R&D advances, such as the availability of Federal or State financial assistance. They indicated that plant expansion and new construction will continue through 1980.

Municipalities that have made progress in sludge handling and disposal did so by improving dewatering, changing to incineration, or changing from incineration to disposal on land. Several municipalities said their progress resulted from improved technology.

Many municipalities had not taken action to control combined sewer discharges and progress had been slow for those that had. For example, one municipality which has been separating its combined sewers since 1950 had reduced 83 miles of combined sewers to 60 miles in 1972 and estimated that it would cost $30 million more to eliminate combined sewer discharges. Only a few municipalities indicated progress in nutrient removal and they attributed it to improvements in using chemicals for phosphorous removal.

Except for nutrient removal, municipalities indicated progress was hindered by insufficient Federal or State construction grant funds and an inability to finance the construction themselves.

EPA TECHNOLOGY DEVELOPMENT PROGRAM FOR MUNICIPAL WASTE WATER TREATMENT

According to EPA, its municipal R&D program is concerned primarily with:

--Exploratory research of new and imaginative water pollution control methods.

--Engineering development of these methods to solve the problems of bringing an idea from the laboratory to small-scale use.

--Demonstration of the new technology to show potential users that it is available for widespread, full-scale application.

However, there has been little change in the processes for dealing with municipalities' major water pollution control problems. R&D programs for controlling municipal water pollution have emphasized improving individual processes to achieve higher pollutant-removal rates and demonstrating existing technological alternatives. Few of the recent results of municipal technology R&D programs have been broadly implemented because of the high cost. (See ch. 3.)

R&D RESULTS IN PROBLEM AREAS REVIEWED

EPA has spent $140 million for municipal technology R&D since 1966. We selected for detailed review three problem areas where a significant portion of these funds has been applied.

	Amount (millions)
Combined sewers and storm runoff discharges	$43.1
Sludge handling and disposal	8.2
Nutrient removal	8.2
Total	$59.5

Combined sewers and storm water discharges

During March 1970 hearings by the Subcommittee on Air and Water Pollution, Senate Public Works Committee, the Director, Association of Metropolitan Sewerage Agencies, stated that combined sewer discharges caused 40 to 50 percent of the pollution in all waterways in metropolitan areas. He said that, unless the problem was corrected, the public probably would not see benefits from any pollution abatement facilities now planned or recently built in metropolitan areas having combined sewers.

According to EPA, discharges from combined sewers are a major source of water pollution primarily in the Northeast and Midwest. Combined sewers carry domestic and/or industrial wastes and, during storms and thaws, also carry polluting runoffs. The normal flows in combined sewers, relatively low and slow moving, permit a buildup of solids in the systems. During storms the flows can increase as much as 100 times the normal flow. The high flow and fast movement flush solids from the sewers.

Sewers and sewage treatment facilities usually have some excess capacity but cannot handle the increased flows that occur during storms. To avoid overloading the sewers and the treatment facilities, combined sewer systems have diversion facilities which allow part of the stormflow to be discharged directly into waterways. These diverted flows consist of a mixture of untreated sewage and storm runoff. Even when all, or a significant part, of the stormflows are routed through the treatment facilities, the facilities' efficiency may be severely reduced and the resultant discharges may be of lower quality than those occurring during dry-weather conditions.

A 1967 report by the American Public Works Association stated that about 54 million people lived in municipalities partially or wholly served by combined sewer systems and that the Nation had about 55,000 miles of combined sewers. The report estimated that it would cost $48 billion to solve the problems by sewer separation and $15 billion by alternative methods, such as storage and treatment. EPA officials stated that these costs had increased to about $70 billion and $25 billion, respectively, due to increased construction costs.

Some communities separate their sewers because it requires less operation and maintenance costs, which municipalities have to pay, than alternative methods. It also may solve other sewer problems, such as deterioration and undercapacity.

EPA spent more than $40 million (about 32 percent of the total funding for municipal technology R&D) on the combined sewers problem from fiscal year 1966 through 1972. It funded 95 extramural projects, totaling about $35 million, which included research on:

--off-system and in-system storage;

--screening and physical-chemical and other treatment methods;

--flow control methods, e.g., diversion, regulation, and drainage; and

--evaluation and problem-defining research, including mathematical models and methods for measuring flows.

EPA awarded 21 R&D demonstration grants totaling about $14 million for storing combined sewer flows. However, State agency officials in New York said that storage was not new and should not be included in EPA's research program. Columbus, Ohio, for example, constructed underground storage facilities in 1934.

Alternative methods to off-system storage that EPA funded include in-system storage, various treatment techniques, and flow regulation. These methods reduce the frequency of discharges but still must be coupled with some form of storage to totally solve the problem.

The main thrust of EPA's efforts in the combined sewers area has been the refinement and repeated demonstration of a number of methods which essentially are not new. Such demonstration, using conventional-type construction with minor modifications, was not, in our opinion, the most cost-effective use of municipal technology R&D funds. In responding to our questionnaire, one municipality stated:

> "The design and construction of facilities to handle a significant part of the combined sewer problem was achieved through engineering technology available prior to Federal RD&D in water pollution control."

EPA construction grant officials were not able to identify the municipalities using or planning to use the demonstrated methods to solve their combined sewer problems.

In our May 28, 1973, report to the Congress entitled "Need to Control Discharges From Sewers Carrying Both Sewage and Storm Runoff" (B-166506), we stated that combined sewer discharges of untreated or inadequately treated sewage was a major pollution problem and prevented many municipalities from attaining Federal and State water quality goals. We further concluded that Federal and State agencies had placed little emphasis on abating and controlling combined sewer discharges, primarily because of the high cost. In some instances, EPA funded projects under its R&D and construction grant programs, but generally construction grant funds were not available.

Nutrient removal

Nutrients are needed to maintain an ecological balance in a body of water, but excessive quantities accelerate the growth of algae and other plants. Sewage contains large amounts of nutrients, such as nitrogen and phosphorus, which are prime causes of excessive fertilization. EPA funded 43 extramural R&D projects for removing nutrients during fiscal years 1967-72.

Nutrient	Number of projects	Cost (millions)
Phosphorus	28	$3.6
Nitrogen	15	2.3
Total	43	$5.9

Three of these projects included developing technology for removing both nutrients. In addition, EPA spent about $1.8 million for in-house research. Some multipurpose projects have also included nutrient removal technology as part of their objectives. An EPA official stated that EPA concentrated more on phosphorous removal because phosphorus was considered to be the limiting nutrient, and enforcement conferences for the Great Lakes had emphasized the need for removing it.

Through 1972, EPA awarded construction grant funds to 72 municipalities to construct waste treatment facilities which would be able to remove phosphorus. Sixty-five of these municipalities are located in the Great Lakes area.

Phosphorus

The phosphorus removal technology demonstrated by EPA consists of adding chemicals, such as lime, iron salts, and aluminum salts, which combine with phosphorus and solids and cause the phosphorus to settle out of the waste water. Removing phosphorus by chemical precipitation is not new. The first technical paper on removing phosphorus by adding iron was published in 1944, and the first technical paper on using lime to remove phosphorus was published in 1947. Full-scale phosphorus removal by chemical precipitation was demonstrated in Ottawa, Canada, in 1953.

One of our consultants, in evaluating EPA's research efforts on phosphorus removal, stated that:

> "In view of the extensive information already in the literature on phosphorus removal in a wide variety of locations it would be wise to confine expenditures for research on this subject to projects which indicate that innovative approaches or ideas are to be explored."

Nitrogen

Nitrogen is more difficult to control than phosphorous because it can enter the water from the atmosphere. Therefore EPA enforcement actions have concentrated more on phosphorus removal. EPA officials stated that full-scale demonstration projects are needed for nitrogen removal.

The nitrogen control technology demonstrated by EPA may be broadly classified as biological and physical-chemical. The major processes developed or demonstrated by EPA consist of (1) air stripping of ammonia, (2) biological nitrification-denitrification systems, (3) ion exchange, and (4) breakpoint chlorination. The physical-chemical nitrogen removal processes--ion exchange and breakpoint chlorination--usually require a prior biological process to convert the nitrogen to the correct form.

EPA planning documents prepared in April 1972 pointed out that problems were being encountered with physical-chemical processes.

> "In most cases side reactions or residues complicate the process, or economics are unfavorable. Additionally, ammonia stripping discharges ammonia to the atmosphere. Work is needed to develop these processes or to find an entirely new route of nitrogen control."

In a November 1972 technology transfer seminar, EPA pointed out some of the limitations of nitrogen removal processes.

--Air stripping of ammonia cannot be recommended for wide application in the United States because of the temperature limitation and scaling problems.

--Breakpoint chlorination increases the total dissolved solids content of the effluent and therefore may have limited application for ammonia removal.

--Ion exchange materials result in a nitrogen-rich brine solution which must be disposed of.

At Lake Tahoe, California, EPA funded about $1 million of a $2 million project which included using ammonia-stripping towers to remove nitrogen from tertiary effluent. The process removed 30 to 90 percent of the nitrogen at a cost of about 1.8 cents per 1,000 gallons of waste water treated. However, problems were encountered because the nitrogen towers froze during cold weather.

EPA also funded a $1 million project at Manassas, Virginia, which used both nitrogen and phosphorus removal processes. A biological nitrification-denitrification pilot plant was developed in which multimedia filtration for greater nutrient removal was studied. The demonstration was completed June 30, 1971.

Although new technology is needed, EPA reduced the program director's $1,458,000 request for nitrogen removal for fiscal year 1973 to $345,000--a 76-percent reduction--because of funding limitations. Therefore no new projects were planned for fiscal year 1973. The funds available were used to continue studies conducted at EPA pilot plants.

Sludge handling and disposal

Sludge is the semiliquid solid matter separated from waste water by the treatment process. Sludge handling refers to the treatment steps from solids collection to ultimate disposal of the residue. Dewatering sludge before disposal is a common processing step and accounts for the major cost of sludge handling.

Sludge volume increases significantly with each increase in the level of treatment. For example, secondary treatment increases the amount of sludge produced by primary treatment. EPA estimated that the volume of sludge would increase from about 5 million tons a year in 1972 to 10 million tons a year in 1985.

A 1968 EPA state-of-the-art study stated that most methods of sludge handling and disposal were known in 1939 and that new approaches were needed. This study concluded that:

> "The cost and troublesome nature of existing handling and disposal processes warrant a large research effort. In the future, the situation could be more critical if new techniques are not developed because sludge volumes are rising and

> increased wastewater treatment efficiencies are producing more difficult to handle sludge."

An April 1972 internal EPA report on sludge disposal alternatives stated that the only significant changes since the 1968 study were the increased cost of sludge handling and the increased volume of sludge produced.

Although sludge volumes have increased, EPA's funding for sludge research has decreased by about 70 percent--from $2.6 million in fiscal year 1968 to $668,000 in fiscal year 1973. For fiscal years 1968-72 EPA spent $7.5 million on sludge handling and disposal research; $6.7 million was for 45 extramural projects and the remaining $0.8 million was spent in-house. The major emphasis of this research was to provide a better understanding of sludge processes to improve their operational efficiency.

The objective of EPA's 1973 sludge research program was:

> "* * * to develop new or improved sludge handling, disposal, and utilization technology so that the municipal sector will be able to achieve compliance with present and future water quality standards."

In the fiscal year 1973 municipal technology program, sludge handling and disposal was the highest research priority. Of 47 research plans funded for fiscal year 1973, 6 concerned sludge research. The $789,000 budgeted for these six plans represented a substantial reduction from the $3.4 million requested by field officials. The total amount assigned to sludge research was further reduced to $668,000 because funds were reprogramed and one research plan was discontinued. The program was primarily a continuation of projects begun in prior years.

Our consultant on sludge handling and disposal believed that the overall objectives of the research program, as well as the individual research plans, provided a framework within which the necessary R&D could be accomplished. He pointed out, however, that inadequate funding by EPA and the lack of new ideas would tend to hinder EPA from attaining these objectives quickly.

An EPA field official told us that EPA's sludge disposal research emphasized the land application of sludge, which must be demonstrated to win public acceptance. EPA estimated that 60 percent of all the sludge produced in this country is disposed of on land. We identified five projects totaling $1.8 million which were initiated between fiscal years 1968 and 1972 to demonstrate sludge disposal on land. Two more projects totaling $78,000 were initiated to study spreading practices and equipment. All were active in fiscal year 1973. An additional $50,000 was provided in fiscal year 1973 for further research on the land application of sludge.

Ocean dumping has been the least costly means of sludge disposal for many coastal municipalities, including such large metropolitan areas as New York City and Los Angeles. EPA estimated that 15 percent of all sludge is disposed of at sea, and the President's Council on Environmental Quality reported that 89 percent of the sludge dumped at sea is dumped off New York harbor. The Council predicted in October 1970 that the volume of ocean-dumped waste would greatly increase due, in part, to the lack of nearby landsites. However, the expected restrictions on, or even elimination of, dumping sludge into navigable waters as a result of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1401, Supp. II, 1972), and the Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251, Supp. II, 1972), coupled with the lack of nearby landsites, increases the need for innovative solutions to the sludge disposal problem.

APPLICATION OF RESULTS

On November 21, 1972, we issued a report to the Congress entitled "Need to Improve Administration of the Water Pollution Research, Development and Demonstration Program" (B-166506). In the report we stated that many demonstration grants had been awarded for constructing and operating full-scale conventional waste treatment facilities which did not demonstrate new or improved waste treatment processes but rather modified or extended conventional processes. Our review of EPA's research on combined sewers, sludge handling and disposal, and nutrient removal showed that this situation has not changed and results have not been applied on a broad basis.

According to municipalities, the major factor limiting their implementation of new or existing technology was the lack of funds to finance construction. This is discussed more in chapter 3. Some other reasons municipalities gave as to why they had not broadly applied new technology included:

- --Many States had not required municipalities to construct advanced waste treatment plants which would use new technology.
- --Certain pollution problems which R&D had solved were not common to all municipalities.
- --Benefits would be marginal.
- --There had been little pressure through enforcement actions requiring the removal of certain pollutants (nitrogen) through the use of new technology.

EPA has established a technology transfer program in OR&D to overcome the resistance of municipalities and consulting engineers in accepting new technology. The program transfers new technology through seminars which provide detailed information for designing municipal waste treatment plants. To foster an understanding of new technology, this program is also directed toward the nonengineering decisionmakers, i.e., mayors, city managers, etc.

Since the program began in 1971, 36 municipal seminars have been held and attended by about 5,400 engineers. Aided by the pressure of enforcement activities, the program is moving technology from the R&D stage to practical application faster. During fiscal year 1973 there was evidence that the program has increased the amount of technology transferred.

R&D IN CERTAIN AREAS HINDERED BECAUSE OF INDEFINITE POLICY

R&D in some problem areas has been hindered because of EPA's indefinite policy as to research needs in these areas. As a result, EPA's Municipal Pollution Control Division has not been able to decide what research, if any, should be undertaken. The following sections discuss the indefinite policies in regard to stabilization ponds and mercury in sediments.

Stabilization ponds

Stabilization ponds or lagoons are large impoundments constructed to hold raw sewage for removing solids and oxygen-consuming matter naturally. This method has the advantage of low capital, operating, and maintenance costs. The main disadvantage for large municipalities is the large land requirement. About 4,500 stabilization ponds serve about 7.3 million people. Although the ponds account for 32 percent of all municipal sewage treatment plants, they serve only 4 percent of the population served by sewers.

A conflict has existed within EPA as to whether the ponds meet EPA's secondary treatment requirement of 85-percent BOD removal. The Office of Water Programs (OWP) believes that upgrading ponds should be a high priority because pond treatment levels do not meet the removal requirement. OR&D believes that this method of treatment comes very close to fulfilling the requirement because it removes an average 83 percent of the BOD. An EPA official told us, however, that stabilization ponds will not meet the new EPA definition of secondary treatment.

EPA's research plan for stabilization ponds included the following statements on the need for a policy decision.

> "No significant progress has been made. Only one project has been funded in the past five years. Much of the inactivity can be traced to an apparently unresolved agency policy regarding the status of ponds and lagoons.

* * * * *

> "It is not clear yet, for instance, whether or not lagoons are considered by the agency to be an acceptable form of secondary treatment and further, whether new lagoon construction will be approved in the future, thus necessitating research programs to improve lagoon design as well as meet the established need of upgrading existing lagoons.

* * * * *

> "Many grant applications and contract proposals to do experimental work on ponds and lagoons have been received over the years with little or no response and guidance from Agency management."

EPA research on stabilization ponds began in fiscal year 1967. Since then only one $67,000 project has been funded. The project's prime objective was to improve pond performance during winter months in areas of severe climate. The only other R&D considered was on removing algae and other organic solids from pond effluent.

Stabilization pond research was the third highest priority in EPA's 1973 municipal technology research program. However, only $113,500 of about $500,000 requested was allocated to this research area during the fiscal year 1973 initial planning. The program's inactivity and limited funding resulted from the conflict.

Agency actions

In October 1973, EPA officials expressed the view that, with proper design and operation, stabilization ponds can meet secondary treatment requirements and that, as a result, a major R&D effort is underway to find ways to improve stabilization pond systems. EPA stated that approximately $317,000 has been allocated for this research and there are three R&D projects in process.

Mercury in sediments

The sediment in the Nation's waterways contains mercury deposits that will remain after discharges of mercury have been stopped. These mercury deposits can change into highly toxic methyl mercury and enter the aquatic food chain. EPA was aware of this problem and in August 1970 stated that:

> "Methodology needs to be developed for removing, stabilizing or inactivating these mercury deposits so that they will not continue to be a pollution problem."

In March and June 1971, EPA awarded six contracts totaling $400,000 to develop methods to neutralize or remove mercury deposits. EPA officials told us these contracts were awarded as part of a "crash" program responding to the mercury scare of 1970. A field official added that originally several of the more promising results were to be selected for more concentrated effort. All six contracts were completed in fiscal year 1972.

EPA found that by July 1971 mercury discharges into waterways had been reduced by 91 percent as a result of its enforcement actions and industries' voluntary actions. An EPA enforcement official said a second objective of the civil actions was to force industries to clean up the mercury in the sediment but that this objective could not be met because technology for removing the mercury was not available.

An EPA research report published in May 1972 stated that:

> "The sediments of many major inland lakes and streams were found to contain large amounts of mercury. * * * The large quantities of mercury in lake and stream sediments remain a major environmental problem."

The program manager stated that not a single viable method to remove mercury was developed and demonstrated under the six contracts. The responsible EPA program director said the results of the six contracts indicated that a major effort should be directed toward evaluating technology developed under field conditions. A headquarters official added that the contracts warranted further research. Both the program director and the program manager indicated that EPA's Office of Enforcement needed research to resolve pending litigation. An EPA enforcement official confirmed that research was needed to determine the amount of mercury deposits in sediments.

The program director requested $421,000 for fiscal year 1973 and $1.3 million over the following 5 years to (1) continue research on mercury deposits and (2) develop methods to control other toxic materials and nutrients which have accumulated in stream and lake sediments. The research plan warned that:

> "There is a definite need for formulation of an Agency policy related to mercury which is already present in the aquatic environment. In addition, the Agency should establish and sustain a realistic research priority for the mercury problem as concerns amounts accumulated in sediments in the aquatic environment. Solutions in this problem area require a continuing commitment of research resources. The Agency displayed a high level of interest in the mercury problem at the time the six contracts * * * were funded. However, Agency interest in this problem area appears to have withered."

The Federal Water Pollution Control Act Amendments of 1972 require EPA to find the location of in-place pollutants, with emphasis on toxic pollutants in harbors and navigable waterways, and authorize EPA to arrange for their removal and disposal. Despite this presumed high-level need and the program director's warnings, EPA provided only $12,500 for fiscal year 1973.

In defining the research objective for the year, the program manager stated that the minimum acceptable work was to identify the most critical accumulated deposits in the sediments and:

> "* * * to develop, demonstrate and evaluate methods or systems for controlling or eliminating pollution from such sources. Mercury in sediments is an example of a current high level need. * * * A demonstration of a mercury control method must be implemented by September 1972."

However, EPA did not provide funds to identify the most critical accumulated deposits nor to continue research on mercury deposits. A headquarters official told us the low funding level was due, in part, to the fact that the public was no longer concerned about the problem.

The program manager stated that, although the problem of mercury in sediments still exists, the problem has not been sufficiently defined to warrant continued research and research would be discontinued after fiscal year 1973.

NONPOLLUTING DISCHARGES: IMPACT ON MUNICIPAL TECHNOLOGY PROGRAM

The Federal Water Pollution Control Act Amendments of 1972 established a national goal of eliminating polluting discharges into navigable waters by 1985. It also established an interim goal of protecting and propagating fish, shellfish, and wildlife and providing for recreation by July 1, 1983.

To achieve these goals, section 201(g)(2) of the act, which authorizes the construction grant program, states that:

> "The Administrator shall not make grants from funds authorized for * * * treatment works unless the grant applicant has satisfactorily demonstrated to the Administrator that -
>
> > "* * * the works proposed for grant assistance will provide for the application of the best practicable waste treatment technology * * * and
> >
> > "as appropriate, the works proposed for grant assistance will take into account and allow to the extent practicable the application of technology at a later date which will provide for the reclaiming or recycling of water or otherwise eliminate the discharge of pollutants."

EPA R&D to achieve nonpolluting discharges

Although the legislation should have a major impact on the municipal technology program, EPA, as of August 1973, had not defined either "best practicable treatment" or "nonpolluting discharge." A research objective to develop and demonstrate advanced technology to achieve nonpolluting municipal discharges had previously been established by EPA and was the second highest priority in the fiscal year 1973 municipal technology program. EPA funded 45 projects totaling about $18.4 million through fiscal year 1972 and an additional $1.6 million in fiscal year 1973 in this area.

EPA's approach has been to (1) establish water quality standards and (2) demonstrate technology using combinations of existing waste treatment processes, so that municipalities can comply with present and future water quality requirements.

Some of the demonstration projects funded in this area have achieved high pollutant removal levels. Others have removed specific pollutants, such as phosphorus or nitrogen. An EPA official told us that, by demonstrating technology to remove more pollutants, EPA is contributing to the achievement of nonpolluting discharges.

EPA funded a $1.3 million pilot project in Washington, D.C., to provide process and design information for a new facility which is expected to remove 98 percent of the BOD and phosphorus and 90 percent of the nitrogen. The District has selected a plant design which will use the existing primary and secondary treatment systems followed by biological nitrification-denitrification and filtration. Phosphorus would be removed by adding alum or iron salts. The target date for completion was 1975 but, due to a lack of funds, has been extended to 1978.

EPA funded $1.5 million of a $2.4 million project in New York City for an oxygen aeration unit to improve plant performance. A New York official told us that the oxygen aeration unit has removed between 93 and 97 percent of the BOD and solids. The plant previously removed only 36 percent of the BOD and 48 percent of the solids.

EPA's research in this area has resulted in improved treatment processes but has been fragmented mainly because the agency has not defined certain environmental goals, such as nonpolluting discharge. This research program will not be fully effective until EPA clearly defines its goals and objectives and develops a phased strategy to achieve them.

Soil treatment systems as an alternative to nonpolluting discharges

The 1972 legislation has renewed interest in soil treatment systems as an alternative to constructing conventional secondary and tertiary treatment facilities. Because of this interest, we reviewed the background of soil treatment systems and Federal R&D to determine whether the systems are a viable alternative for large urban areas.

Soil treatment systems, an early form of waste water treatment due to their low cost and simplicity, apply waste waters to the land with or without pretreatment; interaction with the soil provides treatment. Various plant life may be used in conjunction with the soil to remove elements potentially harmful to the environment but beneficial to plant growth. Besides providing treatment, soil systems may provide secondary benefits, such as irrigation and water reclamation.

We reviewed the soil treatment research programs of three Federal agencies--EPA, the Corps of Engineers, and the Forest Service.

Soil Treatment Research Cost

Fiscal year	Forest Service	Corps of Engineers	EPA
	(000 omitted)		
1968	$ -	$ -	$ 116
1969	-	-	111
1970	-	-	63
1971	4	-	115
1972	50	193	274
1973	158	619	540
Total	$212	$812	$1,219

The costs shown for EPA include those for the major program established for municipal soil treatment systems. They do not include the costs of a project in Muskegon, Michigan, for which EPA awarded a $2.3 million demonstration grant for studies, drainage wells, and irrigation equipment.

The Muskegon project is a $42 million regional soil treatment facility designed to treat 43 million gallons of waste water a day.

Federal studies of soil treatment systems

The Corps of Engineers began a program in fiscal year 1971 to develop alternative waste water management plans for five large urban areas--Boston, Chicago, Cleveland, Detroit, and San Francisco. These studies indicated that soil systems might be a viable alternative for large urban areas and might be more cost effective in achieving high removal levels. The Federal Water Pollution Control Act Amendments of 1972 direct the Corps to make similar studies for the Lake Erie area and authorize the Corps, when requested by the Governor of a State, to help develop regional waste treatment management plans. The Congress authorized $50 million annually for fiscal years 1973 and 1974 for the Corps' participation in regional planning and $5 million for the Lake Erie study.

The Corps met with EPA officials before beginning its soil treatment research program. After several meetings, a Corps official concluded that the scope of EPA's research on soil treatment systems was too narrow to meet the Corps' needs and that evaluation data on the effects of soil treatment systems on soil and water was practically nonexistent. Corps officials told us in July 1973 that it had been difficult to coordinate research with EPA and that EPA was reluctant to supplement its efforts with the expertise of other agencies.

The Corps published two state-of-the-art studies, constructed a soil treatment test facility, and in February 1972 issued design criteria for soil treatment systems. It plans to continue evaluating the environmental and health effects of discharging waste water on the soil.

EPA's research objective for soil treatment systems is to make sound technology available for designing reliable systems. We believe progress toward this objective, however, has been limited. In-house projects have emphasized evaluations of industrial and feedlot applications of soil systems.

Six contracts and grants were awarded under the program during fiscal years 1968-72. One was to determine the state-of-the-art, two were for technical conferences, another to develop a soil treatment system for slaughterhouse wastes, and a fifth to evaluate the effect of wild rice impoundments on water quality. The sixth project concerned denitrification in the soil during waste water disposal.

Two Federal agencies and at least nine States have issued guidelines, regulations, or design criteria for soil systems based on existing technology. EPA funded one state-of-the-art study to evaluate existing technology for designing and operating land waste water management systems.

EPA's fiscal year 1973 research program is directed at developing design criteria and demonstrating models of soil systems. The program director requested $2.4 million for fiscal year 1973 and $20 million over the following 5 years. He estimated that $1.2 million would be needed to meet the minimum acceptable needs of the research objectives. The director recommended that, if funding were sharply reduced, funds be concentrated on one of three basic soil systems to produce prompt results for potential users. However, EPA headquarters' officials allocated $540,000 for soil treatment research and all three approaches were funded. Over 60 percent of the funds were used for demonstration grants.

Conflicting opinions between the Corps and EPA

After the Corps published five waste water management plans, the EPA Administrator wrote that the state-of-the-art was not advanced enough to support these plans. He stated that land treatment runs counter to local planning. The EPA Administrator stated that:

> "Until EPA's demonstration project in Muskegon and other projects are operating and evaluated, the applicability and removal efficiency of land disposal in a great variety of cases cannot be definitely stated."

Corps officials maintained that, with available technology and proper design, soil systems could be used in most locations.

Due to controversy over cost estimates in its initial report, the Corps revised the report covering its Chicago study and greatly reduced its estimates.

	Initial report	Revised report	Percent of reduction
	(billions)		
Secondary treatment	$ 4.3	$3.0	30
Soil treatment	14.7	2.0	86

The Corps' original estimate included the costs for six land disposal sites in Illinois. In revising its estimate, the Corps was not constrained by geographical boundaries and used a single disposal site in Indiana, which greatly reduced sewer requirements. In addition, it changed the treatment facilities requirement from 20 advanced biological plants to 8 physical-chemical plants, used actual bid prices rather than cost estimates, considered actual waste water flows, and improved stormwater flow data and industrial recycling.

A Corps official stated that the cost estimates were derived from EPA data. EPA estimated that the most cost-effective conventional treatment alternative would cost from $1.9 to $2.0 billion. The EPA Administrator stated that:

> "* * * the cost estimate for the land disposal project appears to be optimistic. * * * The social costs of land disposal, as exemplified by the Corps' Chicago study, are substantial and perhaps prohibitive."

EPA, using data from the Muskegon project, stated that using soil systems nationwide would be more costly than using conventional methods.

Applicability of soil treatment systems

There are about 360 municipal soil treatment systems in the United States. About 70 percent are in California and

Texas. Soil systems cannot be used everywhere; their greatest potential is in communities of less than 25,000 people or in arid regions where waste waters are a resource. Potentially, soil systems can be used for 10 to 20 percent of the population served by sewers, compared to the present 4 to 5 percent.

The effectiveness of soil systems depends on an area's type of soil, topography, and climate--factors over which man has little control. Large land areas are required which may not be available in or near many municipalities. The long-term effects of applying waste waters to soil are not well known. Other disadvantages include the potential for health hazards, contamination of ground water, polluting runoffs into waterways, and conflicts with other land-use priorities. These disadvantages led to the construction of waste treatment facilities more amenable to engineering control and requiring less land.

Experts on soil treatment systems generally agree that soil systems must be evaluated site by site and that knowledge gained by studying one soil system may not readily be applied to other locations. Nevertheless, EPA's municipal soil treatment systems research has concentrated on one system--that of the Muskegon project. The demonstration grant for the project is nearly twice the amount EPA spent from fiscal year 1968 through 1973 on other municipal soil treatment systems research.

The grant was awarded before EPA determined what data was available from existing municipal soil treatment systems. Our consultant advised us that:

> "While data from any single installation may not be directly useful to others, data from a wide range of installations covering a wide range of soil and waste characteristics would provide valuable guidelines to others. * * * expenditure of the bulk of budgeted funds for a single project, as for Muskegon, is bound to yield far less return per unit of investment than support of RD&D on many smaller projects."

Agency comments--In its letter dated October 10, 1973, the Department of Defense stated that both EPA and the Corps now agree that land treatment is a viable alternative and that it is environmentally sound. Defense further stated that:

> "With respect to the scale of land treatment sites, both agencies now agree that determination of the most desirable alternative technology should await the detailed planning studies for each specific site. The scale of application of the land treatment alternative is important and planners must consider whether the conditions at each particular site are amenable to design, construction, and operation of this technology. Both EPA and the Corps agree that land disposal and other alternatives should be considered on a case by case basis to select the most cost effective solution to individual problems."

FUNDING OF TECHNOLOGY DEVELOPMENT PROGRAM

EPA funding for municipal technology R&D has decreased, while funding for its construction grant program has significantly increased. The following schedule shows the amount of funds provided for construction grants and municipal technology R&D during fiscal years 1967-72 and the percent of R&D funds in relation to construction grant funds.

EPA Funding

	Construction grants	Municipal technology R&D	Percent
1967	$ 150	$26.2	17.5
1968	203	25.2	12.4
1969	214	24.3	11.3
1970	800	18.5	2.3
1971	997	19.1	1.9
1972	2,000	12.8	.6

In fiscal year 1973, EPA obligated about $3 billion for construction grants but funded its municipal technology R&D at only $9.5 million, or about 0.3 percent of the funding provided for construction grants. In comparison, the Department of Transportation's Urban Mass Transportation Administration, which has $1 billion for its annual capital grants program, is spending about 8 percent, or $80 million, on research.

EPA municipal technology R&D can also be compared to the national average for industry, which is about 4 percent of net sales for research. Some major industries exceed the national average, as can be seen by the following data for 1970, the last year for which figures are available.

Industry	Funds for R&D as a percent of net sales
Aircraft and missiles	18.3
Electrical equipment and communication	7.5
Professional and scientific instruments	5.9
Machinery	4.2
Chemicals and allied products	4.1

EPA officials responsible for developing research plans estimated the following funding needs for fiscal years 1973-78 to meet municipal technology development objectives.

Fiscal year	Estimated funds needed
	(millions)
1973	$ 34.5
1974	42.9
1975	50.7
1976	43.5
1977	27.9
1978	25.4
Total	$224.9

Only $9.5 million, or 28 percent, of the $34.5 million requested by EPA program directors was funded by EPA in fiscal year 1973. At the present funding level, it would take about 24 years to carry out the research program planned above. Although we are not suggesting what the actual funding level for municipal technology should be, significantly more than the fiscal year 1973 funding level may be warranted.

CHAPTER 3

MINIMIZING THE COST OF WATER POLLUTION CONTROL: A CHALLENGE FOR THE MUNICIPAL TECHNOLOGY DEVELOPMENT PROGRAM

EPA R&D resources have generally been applied in major pollution problem areas of concern to municipalities, e.g., combined sewer discharges, sludge handling and disposal, and nutrient removal. Much of EPA's municipal technology R&D has been directed toward developing and demonstrating technology to achieve high treatment or removal levels, but implementation is costly.

One of the primary objectives of the municipal technology program should be to find ways to minimize the cost of municipal pollution control, either by modifying existing technology or by developing new techniques. Two benefits can be obtained by minimizing the cost of control processes: (1) reduced costs would enable municipalities to more easily finance control facilities, which should increase the probability of earlier construction and (2) because the Federal Government provides 75 percent of the cost to construct municipal waste water treatment plants, reduced costs would permit a wider distribution of Federal funds to construct more treatment plants.

NEED TO EMPHASIZE MINIMIZING MUNICIPAL POLLUTION CONTROL COSTS

We believe that the primary objectives of the technology development program for municipal waste water treatment should be to find ways to

- --control pollutants that have not been controlled before because technology was not available;
- --increase the rate of pollutant removal by improving treatment processes; and
- --minimize the cost of pollution control, either by modifying existing technology or by developing new techniques.

Our review showed that a major impediment to greater municipal progress has been the high cost of implementing technology, not the lack of technology. In each of the three areas we reviewed in detail--sludge handling and disposal, combined sewer discharges, and phosphorus removal--it was not evident that EPA had adequately emphasized minimizing costs.

EPA officials told us that cost effectiveness and cost reduction are inherent in engineering activities and that therefore it is difficult to identify these efforts in the municipal technology program. EPA officials in charge of these programs pointed out that the need for cost reduction was recognized and that cost effectiveness was applied in the program. They stated that the programs were directed at developing treatment processes which led to higher pollutant removal levels. These treatment processes frequently were more costly than existing processes which removed less pollutants.

We recognize that higher pollutant removal levels will probably increase the total cost of municipal water pollution control. In fact, it is these increased costs that make minimizing the cost of pollution control processes necessary. Although cost reduction effects may be inherent in engineering activities, we believe that such efforts should be made visible and be a stated prime objective of the municipal technology program.

Sludge handling and disposal

A 1968 EPA study on the state-of-the-art on sludge handling and disposal identified the sludge process as a costly operation. A 1972 EPA report on sludge disposal alternatives stated that:

> "The overall situation on sludge disposal has not changed for 20 years. It is still the most costly, most technically stagnant and most ignored area of water pollution control. Until very recently even EPA's research and development program itself tended to minimize the importance of sludge handling and disposal in consideration of advances in wastewater treatment technology."

This report stated further that the cost of sludge handling had increased since the 1968 study. The report identified research needs for sludge disposal alternatives, but none were directed specifically toward reducing sludge handling costs.

A list of sludge handling and disposal research needs prepared by the Municipal Pollution Control Division in 1972 likewise did not specify cost reduction as a need. However, over 50 percent of the research needs statements on sludge, prepared for fiscal year 1973 municipal technology planning, did identify the need for cost reduction. Our consultant on sludge R&D programs told us that:

> "* * * it is necessary that treatment and handling costs be reduced if we are to achieve the goals now sought. In this sense, all RD&D on other than basic understanding should have decreased costs as one of the evaluation criteria."

Our review of the 45 extramural sludge projects undertaken by EPA for fiscal years 1968-72 showed the following primary objectives.

	Sludge handling		Sludge disposal		
	Number of projects	Cost	Number of projects	Cost	Total cost
		(millions)		(millions)	
Minimize municipal pollution control costs	-	$ -	4	$0.4	$0.4
Improve the operational efficiency of sludge processes	12	2.1	-	-	2.1
Attain a better understanding of sludge processes	17	2.1	7	.3	2.4
Demonstrate the uses of sludge on the land	-	-	5	1.8	1.8
Total	29	$4.2	16	$2.5	$6.7

Although only four projects had cost reduction as an objective, others had some potential for reducing costs. Minimizing costs was not, however, a stated objective of those projects.

EPA identified only 1 of the 45 projects as having an immediate impact on minimizing municipal costs, and only 2 municipalities used the project results. EPA officials cited four other projects as having potential for minimizing costs; work on each of these was continued into fiscal year 1973.

Two other fiscal year 1973 research efforts were oriented toward reducing costs but neither were fully implemented. One was to develop and demonstrate new or improved technology to recover useful materials in sludge. The research, however, was discontinued after funds were reprogramed during the fiscal year. The objective of the second effort was to develop and demonstrate less costly methods of sludge handling and disposal. Funding, however, was approved only for in-house work to complete a report on metals in sludge, to conduct a field investigation of sludge thickening and dewatering characteristics, and to provide more funds for an existing contract.

The high cost of sludge handling and disposal is well-recognized. Much of EPA's program, however, has emphasized providing a better understanding of sludge processes and demonstrating disposal of sludge on land. Therefore little has been achieved to reduce or minimize the cost of sludge handling and disposal.

Combined sewer discharges

Historically, separating sewer systems has been the approach followed to control combined sewer discharges. EPA estimates that separating sewer systems (to control combined sewer discharges) would cost more than $70 billion nationwide and, in many cases, might be impractical. Other alternatives could reduce the cost to about $25 billion, according to EPA.

As for technology being available to control combined sewer problems, an EPA Regional Administrator stated that:

> "Technology is not the critical factor. Rather, these problems are significant primarily because of the massive scale of investment which will be required to implement necessary solutions, investment levels which may severely distress the long-term funding ability of many local governments."

A 1964 EPA report identified a number of storage treatment methods as alternatives to sewer separation. Since 1966 EPA's combined sewer R&D program has emphasized demonstration grants to fund these alternatives.

The following table summarizes EPA extramural projects by research objectives. A small part of the data is applicable to separate storm water discharges.

Project objectives	Number of projects	Cost
		(millions)
Develop and/or demonstrate less costly solutions to problems	8	$ 1.7
Develop a better understanding of the problems resulting from overflows and the required solutions	33	5.8
Study the feasibility of alternative solutions to the problems	17	2.5
Demonstrate alternative solutions	37	25.1
Total	95	$35.1

Only about 5 percent of the funds were used for projects that specifically were to develop and demonstrate less costly solutions.

The $25 billion cost to control combined sewer discharges using alternatives to sewer separation is formidable. For example, EPA funded $1 million of a $4.3 million project at Boston to demonstrate the use of detention tanks to intercept peak flows and to chlorinate waste water as a means of reducing pollution from combined sewer discharges. However, the project takes care of only part of the overflow problem in the metropolitan area. A municipal official estimated that the cost for the total Boston area would be about $750 million.

A $1.5 million demonstration grant was awarded in June 196[illegible] for a project in Chicago to construct underground tunnels for storing excess combined sewer flows. The total cost of this project was about $20 million. The cost of a tunnel storage system for the entire metropolitan area is estimated to be more than $1 billion.

Phosphorus removal

EPA has funded 28 R&D projects totaling about $3.6 million for phosphorus removal technology. The following table summarizes the projects by research objectives.

Research objective	Number of projects	Cost
		(millions)
Develop and/or demonstrate less costly solutions	2	$0.4
Obtain a better understanding of processes	11	.8
Study the feasibility of processes	8	.7
Demonstrate chemical precipitation and other methods	7	1.7
Total	28	$3.6

One of the projects to demonstrate a less costly solution was successful but had only limited applicability to other municipalities. EPA used $46,376 of its demonstration grant funds for a project costing $64,553 in Milwaukee which removed about 91 percent of the soluble phosphorus. Adding pickle liquor--a waste product resulting from immersing metals in acid--converted the soluble phosphorus to suspended phosphates, which could then be removed. The pickle liquor, which a metals firm gave to the municipality, was normally disposed of through landfill after being neutralized at a cost to the firm of about 3 cents a gallon. Milwaukee's cost of removing phosphorus was less than 1 cent per 1,000 gallons of sewage, whereas the average cost of removing phosphorus is about 5 cents per 1,000 gallons.

Although this project achieved a relatively high phosphorus removal rate at a low cost, the probability of applying the method in other municipalities is small because, according to an EPA regional administrator:

> "* * * Pickle liquors would be the treatment chemical of choice only where there already exists a stable local source which could provide

> ferrous salts in this form. This is the only situation which may be ordinarily envisioned in which the costs associated with the use of pickle liquors would be clearly less than the cost of utilizing alternative commerical water treatment chemicals. The availability of waste pickle liquor is not anticipated to have any significant impact on the cost of wastewater treatment for phosphorus removal except in rare localized instances." (Underscoring supplied)

Although demonstrations of other methods of chemical phosphorus removal funded by EPA were technically successful, they were not more economical. For example, data developed at the Lake Michigan Water Pollution Enforcement Conference in 1968 pointed out that adding lime or alum could reliably remove 90 to 95 percent of the phosphorus from waste water but still at about 5 cents per 1,000 gallons. Recent EPA publications show that the overall cost of removing phosphorus is still about the same (5 cents per 1,000 gallons) and more costs (which may be substantial) are incurred for handling the resulting sludge. New York officials stated that the cost of removing phosphorus for its smaller municipalities, where serious problems exist, is much greater than the above figures.

EPA has spent R&D funds for removing phosphorus primarily to obtain a better understanding and to demonstrate variations of known methods of chemical precipitation. However, it has directed only minimal effort to reducing the costs of removing phosphorus.

EPA fiscal year 1973 technology development program for municipal waste water treatment

EPA placed little emphasis on minimizing the costs of municipal waste water treatment in its fiscal year 1973 technology development program. In its Extramural Program Information Bulletin (EXPRO) dated October 1972, EPA identified 20 new tasks planned for the year. Only 1 of the 20 had a goal of developing a more economical solution. (See app. III.)

BENEFITS OBTAINABLE BY MINIMIZING POLLUTION CONTROL COSTS

EPA also needs to consider new and innovative approaches to find ways to minimize the cost of municipal water pollution control. Two benefits can be obtained by minimizing the cost of control processes: (1) reduced costs would enable municipalities to more easily finance control facilities, which should increase the probability of earlier construction, and (2) because the Federal Government provides 75 percent of the cost to construct municipal waste treatment plants, reduced costs would permit a wider distribution of Federal funds to construct more treatment plants, which should result in greater progress toward improving the quality of the water.

Municipal views on the availability and cost of technology

All but 1 of the 81 municipalities answering our questionnaire (see app. II) cited the lack of funds or the high cost of treatment technology as an impediment to resolving their water pollution problems.

We asked the municipalities to indicate for 10 EPA R&D areas whether technology (1) was available but too expensive or (2) was not available. The following schedule shows that most of the municipalities responding believed that the technology was available but too expensive.

R&D area	Percent of responding municipalities indicating technology available but too expensive
Phosphorus and nitrogen removal processes	77
Physical-chemical treatment processes	75
Combined sewer overflows and discharges	72
Advanced biological treatment processes	65
Sludge handling	64
Nonsewered and separate storm runoffs	61
Sludge disposal	58
Municipal treatment of industrial wastes	55
Upgrading efficiency of stabilization ponds	47
Soil treatment systems	36

The number of municipalities responding to our 2 questions concerning the specific areas listed above ranged from a high of 71 for phosphorus and nitrogen removal processes to a low of 32 for upgrading efficiency of stabilization ponds. Some municipalities did not complete, or only partly completed, this section of the questionnaire either because they were not familiar with the problems or the problems did not apply to them.

Although 17 municipalities stated that technology was not available to solve some of their water pollution problems, a majority indicated that problems such as combined sewers, storm water runoff, nutrient removal, and sludge handling and disposal needed R&D to develop more economical solutions. Typical comments from these municipalities include:

> "Control of storm water runoff, combined sewers, infiltration, etc., are technologically feasible; however, economically prohibitive."

* * * * *

> "Many of present methods are too costly especially nutrient removal. Heavy metals, sludge disposal and handling are problems that require more research."

* * * * *

> "There is no economically feasible method of eliminating combined sewer overflows or handling sludge in large quantities at the present time."

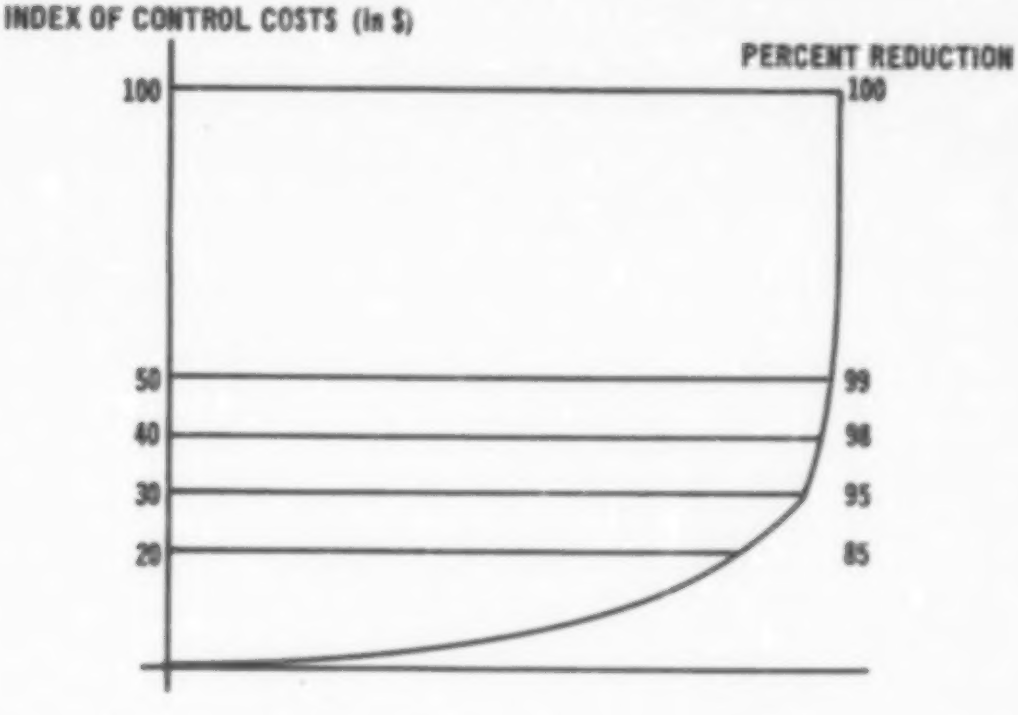
Cost savings to Federal Government and municipalities

Costs increase rapidly as the percent of pollutant removal increases. The incremental benefits, however, are likely to be modest when compared to the increased costs. Municipal progress in implementing processes that remove higher levels of pollutants would be greater if the costs of pollution control were minimized.

The National Water Commission, in a report to the President and the Congress dated June 1973, stressed the importance of considering the costs to the Nation of achieving alternative levels of water quality improvement as well as the beneficial effects to be realized. EPA, in its 1972 report entitled "The Economics of Clean Water," stated that:

> "The ultimate goal of any pollution control program is to achieve certain environmental quality objectives. * * * The least costly method meeting these objectives is to tailor effluent reductions to meet those ambient objectives. To the extent the effluent reductions are more stringent than those which are required, excessive costs are incurred needlessly. This is particularly true at high control levels where control costs escalate very rapidly."

The cost to remove higher percentages of pollutants increases dramatically after secondary treatment (85-percent removal), as illustrated by the following chart.



Source: "The Economics of Clean Water," EPA, 1972.

Another view of the cost of achieving high pollutant removal levels is included on page 43. Prepared from data provided by EPA's Municipal Pollution Control Division, it shows the percentage of removal of BOD and chemical oxygen demand (COD) with the related cost of removal. It shows that the last 9.7 percent of BOD removal accounts for about 43 percent of the total treatment cost. Similarly, the last 13 percent of COD removal accounts for 51 percent of the total treatment cost.

IMPACT OF THE 1972 AMENDMENTS ON COSTS

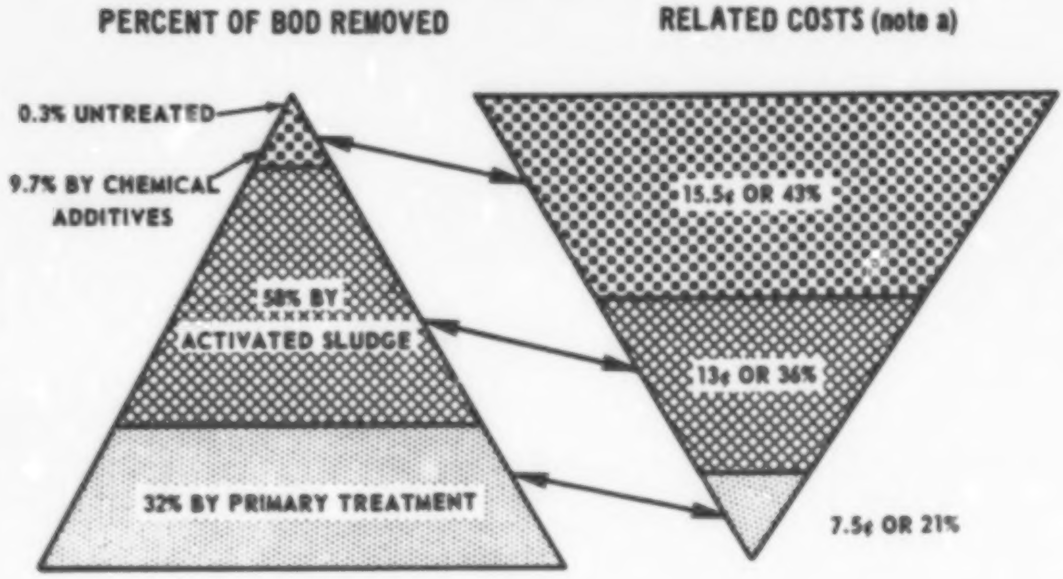
As we indicated in chapter 2, the Federal Water Pollution Control Act Amendments of 1972 estabished a goal of achieving nonpolluting discharges by municipalities by 1985. The act authorized $18 billion for the EPA construction grant program for fiscal years 1973-75. EPA estimated in 1972 that it would cost $153.8 billion ($71.5 billion in capital costs and $82.3 billion in operating costs) for municipalities to achieve zero discharge by 1981.

In a November 1973 report to the Congress, prepared pursuant to sections 205 and 516 of the act, EPA estimated that the cost of constructing publicly owned treatment facilities needed in each State would be $60.1 billion. This estimate was based on a nationwide survey of municipal treatment authorities conducted by EPA through the water pollution control agencies of each State.

The Congress has recognized the high cost of achieving its goals by authorizing $5 billion in 1973, $6 billion in 1974, and $7 billion in 1975 for grants to construct municipal treatment facilities. The act also made collection sewers eligible for construction grants. The goal will require municipalities to build more facilities to increase their level of sewage treatment.

Altogether, the act provides for an ambitious program in a relatively short time frame. In its Water Strategy Paper dated February 1973, EPA recognized that, for the program to have the most impact on water quality, construction priorities must be established and construction costs must be minimized. Minimizing the cost of pollution controls will increase the likelihood that municipalities will construct treatment plants sooner than has been experienced in the past.

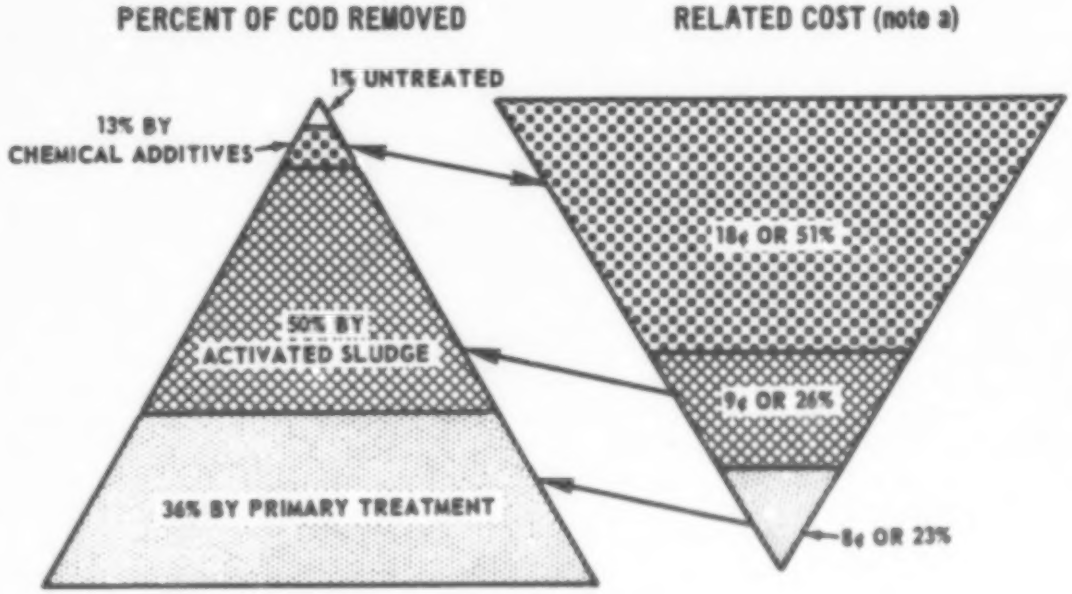
PERCENT OF POLLUTANTS REMOVED AND RELATED COSTS



PERCENT OF BOD REMOVED

RELATED COSTS (note a)

0.3% UNTREATED
9.7% BY CHEMICAL ADDITIVES
58% BY ACTIVATED SLUDGE
32% BY PRIMARY TREATMENT
15.5¢ OR 43%
13¢ OR 36%
7.5¢ OR 21%



PERCENT OF COD REMOVED

RELATED COST (note a)

1% UNTREATED
13% BY CHEMICAL ADDITIVES
50% BY ACTIVATED SLUDGE
36% BY PRIMARY TREATMENT
18¢ OR 51%
9¢ OR 26%
8¢ OR 23%

a/ Cost per 1,000 gallons of sewage treated.

CHAPTER 4

PROBLEMS IN R&D PLANNING AND CONFLICTS WITH OTHER AGENCIES

Our comments on EPA's planning for its municipal technology program and instances of conflicts between EPA and other Federal agencies are set forth in the following sections of this chapter.

PLANNING AND PROPOSAL SOLICITATION

In some cases, EPA did not plan its municipal technology development program for fiscal year 1973 according to OR&D's planning procedures and did not adequately consider resource requirements and priorities identified by program personnel. In addition, EPA's planning and solicitation procedures kept it from accepting extramural proposals which did not follow its prescribed approaches for solving specific problems. Procedural changes made since the fiscal year 1973 plan was completed should help to improve such planning in the future.

Municipal technology development planning

The research planning system EPA used in fiscal year 1973 was designed to assist:

> "*** in meeting the research needs of the Agency and the Nation through a formal process of identifying research needs, defining specific research objectives, developing detailed plans to accomplish defined objectives, establishing priorities, and assigning resources and responsibilities for executing approved plans."

OR&D fiscal year planning begins with identifying research needs submitted by EPA and non-EPA sources. Senior regional, National Environmental Research Center (NERC), and headquarters officials review these R&D needs and set priorities. Headquarters' program managers also review needs and develop specific research objectives.

Field officials, who implement the research programs, plan the tasks and estimate the funds needed to achieve the objectives. The responsible NERC director must approve a plan before it is forwarded to the headquarters' program manager. The director certifies that (1) the plan is realistic and achievable, (2) the funds requested will be enough to implement the plan, and (3) the plan can be executed if the funds requested are provided.

The program manager reviews the plans and assigns priorities. A group of senior EPA officials reviews and approves individual plans and priorities and allocates available resources.

For fiscal year 1973, the following sources sent 506 municipal technology needs to the program manager.

Source	Percent
EPA	47
Municipalities	10
Consulting engineers	2
States	20
Others	21
Total	100

The program manager combined similar needs and deleted those that were incomplete, did not require R&D, or were of low priority. Sixty-six objectives statements were prepared; headquarters officials funded 47 plans.

Field officials prepared the plans without funding constraints from headquarters and requested $34.5 million. However, the Municipal Pollution Control Division's budget for fiscal year 1973 was $9.5 million. The basis for approving plans, allocating funds, and selecting tasks was primarily the professional judgments of Municipal Pollution Control Division and other OR&D headquarters officials. EPA did not document, and we were unable to determine, the criteria used in making the decisions.

The municipal technology program manager told us the fiscal year 1973 planning system was a failure. Priorities were not set for the individual tasks in the plans, the plans did not show a logical step-by-step progression to meet an objective, and it was impossible to fund complete plans within the allotted funding.

Another EPA official stated that the objectives were usually broadly written and that there was a strong tendency to prepare and approve plans to continue active projects and to concentrate on narrow aspects of problems. This resulted in approved plans which did not necessarily respond to the needs submitted. For example, EPA region 1 officials stated that approved plans were only about 40-percent responsive to their 10 highest priority needs.

According to EPA's Program Planning Manual, a research plan is the basic unit for program decisions, and all tasks in a plan are essential for successful accomplishment and must be funded. Also, a plan must be approved as a whole, never in part. Of the 47 funded plans, 44 were funded below the levels requested in the initial plans and certified by NERC directors. Individual tasks were added, deleted, or changed during the final approval process. Funding levels considered necessary to meet specific research objectives were reduced by at least 70 percent in 29 approved plans. Funding for 31 plans was much less than that considered necessary to achieve the stated objectives.

Procedures for fiscal year 1974 planning have been changed to require program managers to estimate the funds necessary to achieve specific research objectives. Using objectives statements and the supporting need statements, field officials prepare a summary plan; they can, however, exceed the program manager's funding estimates in preparing the summary. When the summary is approved, funds are allocated accordingly. Knowing the funding, field officials prepare the detailed plan. This change in procedure should overcome the risk of not funding critical tasks and not responding to the needs identified.

The summaries, however, may be too general to give management personnel enough information to make sound funding decisions. An alternative might be for initial plans to be developed on the basis of several funding levels. Management could then (1) identify the individual tasks that field officials consider critical for meeting objectives and

(2) determine the effect of alternative funding levels before making final judgments on funding allocations.

Procedures for soliciting and funding extramural R&D proposals

Greater flexibility is needed in planning, allocating R&D funds, and encouraging and funding extramural proposals that may not be identical to EPA-prescribed approaches. An increased capability to respond to such proposals could encourage more innovation.

The Municipal Pollution Control Division relies to a large extent on external organizations to perform R&D. However, the procedures these organizations have to follow in planning proposals are not conducive to innovative proposals.

In developing individual research plans to implement R&D objectives, EPA allocates or commits municipal technology funds to specific plans and tasks. Extramural proposals are then solicited primarily on the basis of EXPRO, which describes the specific tasks for which proposals are desired. According to EXPRO, fiscal year 1973 municipal technology tasks were to be funded by demonstration grants or contracts. Contracts necessitate competitive bidding before award, unless sole-source award can be justified, and therefore presume a well-defined work scope. However, EXPRO states that unsolicited proposals, i.e., for research not within EXPRO tasks, can be submitted.

Under its present procedures, EPA tends to fund proposals that are in accordance with its prescribed approaches. Proposals not in accordance with the prescribed approaches are funded at yearend when unspent funds are reprogramed.

For example, EXPRO did not include requests for new proposals for research on sludge in fiscal year 1973. According to a program official, unsolicited proposals were received for sludge R&D in 1973. Since funds were available at the end of the year, a $50,000 contract was awarded in June to an engineering firm that had submitted an unsolicited proposal to develop design criteria and prepare a state-of-the-art report on lime sludge recycling. The award was based on sole-source procurement because the firm had accumulated considerable expertise and data on the subject.

Officials of a company in the water pollution control industry told us innovative approaches would be encouraged if proposals to solve problems by any method were sought. Further, our consultants stated that EPA's system did not encourage enough new ideas and approaches. They believed that EPA's objectives should be more general, and unsolicited proposals should be encouraged.

CONFLICTING R&D

EPA has the largest Federal R&D program relating to municipal technology development, but other Federal agencies are doing some research in this area. During our review we noted two instances of conflicts between EPA and other agencies.

Phosphate-free detergents

About 50 percent of the phosphorus in municipal sewage comes from laundry detergents. EPA began a product control technology program in 1969 to develop phosphate-free laundry detergents to reduce eutrophication of the Nation's waters and spent about $800,000 through fiscal year 1973.

The soap and detergent industry and the Department of Agriculture's Agricultural Research Service (ARS) have conducted research to develop phosphate-free detergents. ARS spent about $1.0 million on research to develop phosphate-free detergents during fiscal years 1970-73 and an additional $1.2 million for soap and detergent investigations from 1967 through 1973. According to Soap and Detergent Association officials, the industry has spent about $170 million over the past 10 years to develop phosphate-free detergents.

ARS has done in-house research for at least 30 years to develop new uses for agricultural products. Before awarding a contract in May 1970, EPA contacted ARS officials to see if they were interested in competing for EPA funds to develop phosphate-free detergents. ARS was interested and submitted a proposal to EPA.

EPA officials informed us that they did not award the contract to ARS because they did not consider ARS' approach to phosphate-free detergents, i.e., the use of animal fats, to be the solution to the problem on a national scale. ARS, after learning that EPA would not fund its proposal, went ahead with the research described in the proposal and developed a phosphate-free detergent using animal fats. A large detergent manufacturer was test marketing the product as of June 1973.

EPA awarded its first contract for developing a phosphate-free detergent in June 1969. An EPA official stated that this contract was a limited effort designed to prod industry into accelerating its own research. Another contract was awarded to this contractor in October 1970. Reports were published for both contracts in December 1970 and February 1972, respectively. After evaluating a proposal to demonstrate these contract results, an EPA official stated in April 1972:

> "We [EPA] have decided not to continue this work. The formulation recommended by * * * [the contractor] does not appear to be satisfactory for general household use as its washing ability varies greatly with the type of soil and fiber composition of the fabric."

In May 1970, EPA awarded a contract to develop phosphate-free detergents to a second contractor. An EPA official stated that the interim results of that contract appear promising and may be demonstrated during fiscal year 1974 if funds are available.

EPA and ARS are both trying to develop phosphate-free detergents but apparently disagree as to whether such a detergent using animal fats can be developed and marketed nationally.

Soil treatment systems

The Corps of Engineers and EPA have been doing R&D on the practicability of soil treatment systems. However, the R&D undertaken by these two agencies resulted in a conflict as to the practicability of soil systems in large urban areas. The Corps believed that soil treatment was a viable alternative while EPA believed that the health aspects and cost effectiveness of soil treatment had not been sufficiently researched and demonstrated.

Defense informed us that both EPA and the Corps now agree that soil treatment is a viable, environmentally sound alternative which should be considered on a case-by-case basis to solve individual problems. This matter is discussed in more detail beginning on page 25.

EPA ESTIMATED EXPENDITURES FOR TECHNOLOGY DEVELOPMENT FOR MUNICIPAL WASTE WATER TREATMENT

Fiscal year	Grants	Contracts	In-house	Total
	(millions)			
1966	$ 2.2	$ -	$ 2.6	$ 4.8
1967	17.4	5.8	3.0	26.2
1968	13.3	8.9	3.0	25.2
1969	13.9	8.6	1.8	24.3
1970	9.0	5.9	3.6	18.5
1971	11.4	4.0	3.7	19.1
1972	4.9	4.2	3.7	12.8
1973	[a]5.6	-	3.9	9.5
Total	$77.7	$37.4	$25.3	$140.4

[a] Amount represents both grants and contracts. Individual amounts were not available.

ALPHABETICAL LISTING OF 100 MUNICIPALITIES INCLUDED IN GAO QUESTIONNAIRE SAMPLE (note a)

AKRON, Ohio
ALBUQUERQUE, New Mexico
Anaheim, California
ATLANTA, Georgia
Austin, Texas
BALTIMORE, Maryland
Baton Rouge, Louisiana
BIRMINGHAM, Alabama
BOSTON, Massachusetts
BRIDGEPORT, Connecticut
Buffalo, New York
Charlotte, North Carolina
CHICAGO, Illinois
CINCINNATI, Ohio
CLEVELAND, Ohio
COLUMBUS, Georgia
COLUMBUS, Ohio
CORPUS CHRISTI, Texas
DALLAS, Texas
Dayton, Ohio
DENVER, Colorado
DES MOINES, Iowa
DETROIT, Michigan
EL PASO, Texas
Evansville, Indiana
FLINT, Michigan
FORT LAUDERDALE, Florida
FORT WAYNE, Indiana
FORT WORTH, Texas
FRESNO, California
GARY, Indiana
GRAND RAPIDS, Michigan
GREENSBORO, North Carolina
HARTFORD, Connecticut
HONOLULU, Hawaii
HOUSTON, Texas
INDIANAPOLIS, Indiana
JACKSON, Mississippi
JACKSONVILLE, Florida
Jersey City, New Jersey

[a] Municipalities from whom completed questionnaires were received are capitalized (81 of 100).

Kansas City, Kansas
Kansas City, Missouri
KNOXVILLE, Tennessee
LINCOLN, Nebraska
LONG BEACH, California
LOS ANGELES, California
Louisville, Kentucky
LUBBOCK, Texas
MADISON, Wisconsin
Memphis, Tennessee
Miami, Florida
MILWAUKEE, Wisconsin
MINNEAPOLIS, Minnesota
MOBILE, Alabama
NASHVILLE-DAVIDSON, Tennessee
NEWARK, New Jersey
NEW ORLEANS, Louisiana
NEWPORT NEWS, Virginia
NEW YORK, New York
NORFOLK, Virginia
OAKLAND, California
OKLAHOMA CITY, Oklahoma
OMAHA, Nebraska
PATTERSON, New Jersey
PHILADELPHIA, Pennsylvania
PHOENIX, Arizona
PITTSBURGH, Pennsylvania
PORTLAND, Oregon
PROVIDENCE, Rhode Island
RICHMOND, Virginia
RIVERSIDE, California
Rochester, New York
Rockford, Illinois
Sacramento, California
ST. LOUIS, Missouri
ST. PAUL, Minnesota
ST. PETERSBURG, Florida
SALT LAKE CITY, Utah
SAN ANTONIO, Texas
SAN DIEGO, California
SAN FRANCISCO, California
SAN JOSE, California
Santa Ana, California
SEATTLE, Washington

SHREVEPORT, Louisiana
SPOKANE, Washington
SPRINGFIELD, Massachusetts
SYRACUSE, New York
TACOMA, Washington
TAMPA, Florida
TOLEDO, Ohio
Tucson, Arizona
TULSA, Oklahoma
VIRGINIA BEACH, Virginia
WARREN, Michigan
WASHINGTON, District of Columbia
WICHITA, Kansas
WORCESTER, Massachusetts
YONKERS, New York
Youngstown, Ohio

SUMMARY OF TECHNOLOGY DEVELOPMENT PROJECTS FOR MUNICIPAL WASTE WATER TREATMENT CONTAINED IN EPA'S OCTOBER 1972 EXTRAMURAL PROGRAM INFORMATION BULLETIN

Research objective achievement plan 21AAA: Demonstration of advanced technology to achieve non-polluting municipal discharge

Task number	Task description	Expected funding
21AAA-19	Evaluate and demonstrate irrigation with waste water.	Demonstration grant
21AAA-30	Develop new process trains for small and intermittent flows. (Joint EPA-Department of Housing and Urban Development project)	Demonstration grant
21AAA-36	Demonstrate flow equalization.	Demonstration grant

Research objective achievement plan 21AAF: Storm and combined sewer flow control

Task number	Task description	Expected funding
21AAF-CU	Develop and demonstrate upstream retention, solids, liquid separation, and real-time control with event prediction based on rainfall-runoff history. Conduct hydraulic model studies for upstream subsurface retention and for optimum design of helical regulator. Prototype comparative evaluation of helic, "SWIRL" (vortex), and stilling ponds flow regulator/solids-liquid	Demonstration grant

Research objective achievement plan 21AAF: Storm and combined sewer flow control (continued)

Task number	Task description	Expected funding
	separator. This concept also will alleviate downstream sewerage system overloading.	
21AAF-38	Demonstration and evaluate impregnation of concrete pipe and other methods of infiltration control.	Demonstration grant
21AAF-68	Develop and evaluate methods for determining cumulative runoff volumes with respect to individual and successive storms.	Contract

Research objective achievement plan 21AAG: Application of simulation models to storm and combined sewer overflow

Task number	Task description	Expected funding
21AAG-20	Develop monitoring management system for use in updating dissemination of storm water management model and related models. Specifically, this task will provide continued promotion of usage; further demonstration and evaluation; adaptation and tailoring of the model to meet the requirements of individual situations; user's assistance and training; a viable economic system for model transference; and basic methodology for	Contract

Research objective achievement plan 21AAG: Application of simulation models to storm and combined sewer overflow (continued)

Task number	Task description	Expected funding
	an ongoing, effective implementation program of nationwide applicability	
21AAG-21	Rewrite storm water management model User's Manual to provide a clear, concise document outlining (in complete logical sequence) the analysis required, data inputs, and operating instructions for model use. This effort will include minor updates to the model.	Contract
21AAG-22	Refine and verify the model to include capability to handle surcharge conditions, submerged outfalls in tidal estuaries, and interconnections.	Contract

Research objective achievement plan 21AAH: Treatment of combined sewer overflows

Task number	Task description	Expected funding
21AAH-CP	Develop and refine multiple-use concept for combined sewer overflow treatment-control systems to include means for optimization of municipal sewage treatment (polishing and tertiary treatment), handling dry weather overloads, maintaining greater environmental control by	Demonstration grant

Research objective achievement plan 21AAH: Treatment of combined sewer overflows (continued)

Task number	Task description	Expected funding
	accepting industrial waste, treating liquid waste from municipal air pollution control systems, etc.	
21AAH-09	Develop a program for effective preconstruction and postconstruction evaluation of treatment and control processes. The shock loadings and variations of pollutant loadings with time in combined sewer overflows require field procedures, sampling techniques, and methods which differ from those used for dry-weather flow.	Contract
21AAH-59	Develop, demonstrate, and evaluate, under both wet- and dry-weather conditions, the SWIRL (vortex) device for primary sedimentation, sludge thickening, and grit removal, and universalize the formulation of device dimensions for each application.	Contract
21AAH-80	Demonstrate and evaluate, at full or large pilot plant scale, several control-treatment processes and methods which have been developed or are now being developed at	Contract

Research objective achievement plan 21AAH: Treatment of combined sewer overflows (continued)

Task number	Task description	Expected funding
	small scale. This project is to be coordinated with the two ongoing state-of-the-art and assessment projects on combined sewer overflow management and treatment.	

Research objective achievement plan 21AAI: Treatment of storm water discharges

21AAI-20	Demonstrate "flow-thru" storm water treatment, i.e., economical means of treating variable storm water flow rates and resultant sludge deposits.	Demonstration grant
21AAI-34	Provide a broad scale assessment of managing, controlling, and treating storm water discharges. This work includes evaluating various control and treatment methods, and the results of their use or lack of use, coupled with design performance and cost information. The assessment is to provide information on a national basis.	Contract

Research objective achievement plan 21AAJ: Technology for control of pollution caused by urban nonsewered runoff

Task number	Task description	Expected funding
21AAJ-51	Demonstrate at full scale various methods to control and treat urban runoff. Although this project would emphasize means to reduce nonsewered runoff, the results would contribute to alleviating combined sewer overflows and storm water discharges. Methods would include surface retention, use of porous pavement, and cleaning to reduce pollution and contain storm water.	Demonstration grant
21AAJ-55	Develop and demonstrate alternative materials-methods for highway deicing, e.g., substitute chemicals, spreading apparatus, spreading rates, etc.	Demonstration grant

Research objective achievement plan 21ACU: Waste water system instrumentation and automation

Task number	Task description	Expected funding
21ACU-40	Demonstrate data acquisition for managing and controlling reclamation facilities. Establish system design guidelines which would specify the minimum size and quality of a digital computer required for data	Demonstration grant

Research objective achievement plan 21ACU: Waste water system instrumentation and automation (continued)

Task number	Task description	Expected funding
	acquisition of municipal waste treatment systems. Guidelines should include alternative approaches, economics, operator training, required manpower and skills, and computer maintenance.	

Research objective achievement plan 21ABY: Development and demonstration of soil systems for waste treatment

21ABY-18	Demonstration of infiltration percolation.	Demonstration grant
21ABY-20	Demonstrate infiltration-percolation, spray runoff, or irrigation techniques for applying waste water to land in the Northeast.	Demonstration grant

UNITED STATES GENERAL ACCOUNTING OFFICE

REPORT TO THE CONGRESS

Research And Demonstration Programs To Achieve Water Quality Goals: What The Federal Government Needs To Do

B-166506

ENCLOSURE C

Programs To Control
Water Pollution From Industrial,
Agricultural, Mining, And
Other Sources

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

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VII EPA's obligations for the AST extramural program by fiscal year and program subelements 53

ABBREVIATIONS

AST	Applied Science and Technology
DOD	Department of Defense
EPA	Environmental Protection Agency
R&D	research, pilot, development, and demonstration

CHAPTER 1

INTRODUCTION

This enclosure includes the results of our study of Federal research, pilot, development, and demonstration (R&D) programs to control pollution from industrial, transportation, agricultural, mining oil and hazardous materials spills, and hydrologic modification (sediment) sources. The Applied Science and Technology (AST) Branch[1] administered the Environmental Protection Agency's (EPA's)[2] R&D program referred to as the AST program.

AST PROGRAM ELEMENTS

A discussion of each element of the AST program follows.

Heavy and light industrial sources

Industry is the major source of water pollution. In terms of volume, industrial wastes are about three times greater than municipal wastes. Also, industrial wastes contain all known pollutants. Industrial production, which creates industrial wastes, is increasing three times faster than the population.

Transportation sources

Pollution from these sources consists of sanitary wastes, litter, bilge, ballast discharge, wash waters, engine emissions, and chemicals. These pollutants are discharged from 110,000 commercial vessels, 40,000 foreign ships which enter the United States each year, 1.3 million recreational vessels, and 1,500 federally operated craft. Fuel drainage and gaseous exhaust from watercraft using 7 million outboard engines also pollute water.

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[1] In June 1973, EPA reorganized these R&D activities into the Industrial Pollution and Non-Point Pollution Control Divisions under the Deputy Assistant Administrator for Environmental Engineering, Office of Research and Development.

[2] EPA and its predecessor agencies. (See app. III, vol. 1.)

Agricultural sources

The most significant pollution problems from this source result from inefficient cropping practices, irrigation, and animal feedlots. Improper cropping practices cause streams to carry 1 billion tons of sediment each year. Each 1,000 tons of sediment carries 1,000 pounds of nutrients which disrupt the normal ecological system.

Irrigation is increasing as more land is cultivated. Irrigating in the 16 arid western and northern States contributes about 2 tons of salt a year to waterways for every acre of irrigated land.

Three-fourths of the Nation's livestock are fattened before marketing in confined animal feedlots and produce about 1.3 billion tons of waste each year, much of which enters waterways. These wastes are high in oxygen-demanding organic matter, living organisms (pathogens and others), and nutrients. Animal wastes entering waterways have bee responsible for killing fish, disrupting the ecosystem, and reducing esthetic and recreational values.

Mining sources

The main source of pollution in this area is acid drainage, most of which comes from inactive mines. Nationally it is estimated that mine drainage has polluted 12,400 miles of streams, of which 10,500 miles are in eight States of the Appalachian region. This pollution increases the costs of water treatment and corrodes watercraft and water-handling equipment, but, more significantly, it destroys aquatic life, deters water-based recreation, and decreases esthetic values.

Oil and hazardous materials spills sources

Each year 500 new chemical compounds are produced which are potentially hazardous. Over 2.8 billion tons of hazardous materials will be produced in 1973, and over 4 billion tons are expected by 1980.

During the years 1967-71, six major oil spills, totaling about 48.7 million gallons, required cleanup costing about $17 million. About 10,000 oil and hazardous materials spills occur annually in the Nation's navigable waters. Oil spills are expected to triple over the next 30 years.

Hydrologic modification sources

Sediment from construction, dredging, landfill, and water resources development activities has a significant impact on the hydrology[1] of an area. About 4 billion cubic yards (6.6 billion tons) of sediment are transported annually into the Nation's rivers, lakes, reservoirs, and other bodies of water, and damage has been estimated to exceed $500 million each year.

SCOPE OF REVIEW

Because EPA was established to bring together, within a single agency, the Federal Government's major environmental control programs, our review was primarily concerned with EPA's R&D program to control, prevent, and abate water pollution in the AST area.

We reviewed EPA's AST program for fiscal years 1966-73. We discussed the program with EPA officials and visited EPA laboratories and selected project sites. (See apps. I and II.)

During fiscal years 1966-73, EPA obligated about $96 million for its AST program. We identified five other Federal agencies which obligated about $112 million during fiscal years 1969-73. We were unable to determine the total extent of other Federal agencies' efforts because of differences in classifying R&D projects.

Four consultants assisted us in evaluating the efficacy of technology development in four AST areas: petrochemical, food and kindred products, animal feedlots, and mine drainage treatment. These areas were selected because of their significance as sources of pollution and because of EPA's expenditures in developing control technology.

We asked our consultants to review EPA work plans and to comment on (1) the approach to solve the problems, (2) the completeness of the plans, and (3) the reasonableness of time and funding estimates. Each consultant was also asked to comment on whether the projects funded were necessary and properly directed toward solving the problems. The following schedule shows the number of work plans and projects reviewed and the EPA funding for the four areas.

---

[1] The science dealing with the properties, distribution, and circulation of water.

Area	Number of work plans	Number of projects	Funding
			(millions)
Petrochemical	4	23	$ 3.7
Food and kindred products	8	57	7.8
Animal feedlots	10	30	3.3
Mine drainage treatment	1	33	3.5
Total	23	143	$18.3

We reviewed other agencies' R&D programs to determine their awareness of EPA's plans and program, the extent of their efforts in the AST area, and whether these efforts interfaced with EPA's.

We visited several agency laboratories and discussed their R&D programs with responsible officials. (See app. III.) We sent questionnaires to 74 national industrial associations (see app. IV) and the 50 States to determine the extent of their R&D efforts in the AST area. We also requested comments from the associations and the States concerning EPA's R&D program and their input into EPA's planning process.

CHAPTER 2

EFFICACY OF EPA's AST PROGRAM

The primary objective of the AST program is to support EPA's enforcement and standard-setting activities by developing and demonstrating new technology for (1) abating and controlling water pollution and (2) reducing the cost of waste treatment. Goals were established to achieve this objective for each major source of pollution in the program.

EPA has made some progress in meeting its objective, but much remains to be done. The program's effectiveness was limited because EPA did not (1) consider all pertinent R&D information available from prior R&D work or use the expertise of Federal agencies, private industry, and the States in planning and implementing the program, (2) fund projects with strict regard to their priority status, and (3) make the program fully responsive to its enforcement and standard-setting activity needs.

PROGRAM OBJECTIVES AND GOALS

The Clean Water Restoration Act of 1966 (80 Stat. 1246), which amended the Federal Water Pollution Control Act, authorized grants to demonstrate projects for preventing industrial pollution and for new or improved methods of joint treatment of municipal and industrial wastes.

Notable in the program is the authority to support both pilot-scale and full-scale demonstration projects on advanced waste treatment, waste water renovation, and industrial pollution control. EPA officials said this authority is particularly significant because it permits them to extend research and development results into the demonstration phase. This phase shows what can be accomplished and at what cost.

EPA's program has three distinct phases:

--Exploratory research of innovative water pollution control methods.

- Engineering development of these methods to solve the problems of bringing an idea from the laboratory to small-scale use.

- Demonstration of new technology to show potential users that it is available for widespread, full-scale application.

Since the industrial program's inception, the major goal has been to develop and demonstrate the practicality of closed cycle (or closed loop) systems[1] for all industries. EPA expects to achieve this goal by developing and demonstrating industrial water reuse methods and product and/or by-product methods, both economically and technically feasible. The program has also been directed toward changing manufacturing processes so they will use less water or no water at all. EPA believes that using closed cycles or process changes will be less costly than building and operating pollution treatment facilities and may result in a net profit for some industries.

The major goals in the other program elements are to (1) develop and demonstrate improved management practices and system design modifications, which will minimize or eliminate water pollution, and treatment systems that can control, prevent, and abate water pollution and (2) provide data to establish enforceable water quality standards. (See app. V for a complete list of major objectives for each program element.)

The AST program was primarily an extramural effort. Grants and contracts were awarded to public and private agencies, institutions, and individuals to support R&D projects that were supposed to have industrywide application. EPA did some in-house research, but its in-house staff spent most of the time administering and monitoring grants and contracts.

The following table shows EPA's obligations for its extramural program during fiscal years 1966-73.

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[1] These systems reuse waste water and do not discharge effluents into waterways.

Element	Obligations (millions)
Heavy industrial sources	$20.8
Light industrial sources	18.8
Oil and hazardous material spills	15.6
Mining sources	14.4
Agricultural sources	8.8
Transportation sources	3.3
Hydrologic modification sources	1.1
Total	$82.8

PROGRAM ACCOMPLISHMENTS

As a result of the AST program, technology has been developed and demonstrated to support closed cycle systems for the sugar-beet-processing and fiberglass-manufacturing industries. Effluent limitation guidelines and standards for industry, which EPA's Office of Air and Water Programs is currently identifying and developing, are based on the results of the program. Also, AST personnel are providing technical assistance to EPA's Office of Technical Analysis (Enforcement) and to the Office of Air and Water Programs.

Some industrial processes developed or demonstrated by EPA are being used commercially. For example, the best practicable control technology effluent standard for the potato-processing industry will require the use of a dry caustic peeling process which does not need water. This process is widely used by that industry, and EPA officials believe it may also be applied to support the effluent standards for other vegetable and fruit peeling processes.

EPA officials identified 28 projects in various program subelements which they believe have already demonstrated or, when completed, will demonstrate significant technological advances which will have industrywide application. Some industrial associations supported EPA's belief. For example, 1 association advised us that 5 projects were applicable to 50 to 100 of its members and that 50 of its members were using technology demonstrated by 1 of these projects. Another association commented that some of its members were using the technology of 1 project which was also applicable to at least 110 plant locations. In addition, six associations identified other EPA projects which they believed demonstrated significant technological advances for abating or controlling water pollution problems related to industries in their associations.

On the basis of our review and our consultants' evaluations, we believe EPA has made progress toward solving problems at the AST area. The projects funded in the petrochemical and acid mine drainage treatment areas generally were necessary and well directed and advanced the state of the art. Several of the projects in the food and kindred products area were well directed and had widespread applicability within the industries involved. In the animal feedlots area several projects were beneficial toward identifying and advancing the state of the art. EPA's accomplishments in developing technology to control acid mine drainage are discussed below.

Acid mine drainage

During fiscal years 1967-72, EPA funded 76 extramural acid drainage projects at a Federal cost of about \$11.5 million. Non-Federal funds for these projects totaled about \$7.2 million. These projects were conducted by universities, States, or private firms under 49 grants and 27 contracts. EPA also conducted in-house R&D during fiscal years 1969-72 totaling about \$1.1 million.

The following table shows the areas, number, and cost of extramural projects.

	Number of extramural projects	Project costs		
		Federal	Non-Federal	Total
Research and development:				
Basic research	9	\$ 588,000	\$ 34,000	\$ 622,000
Treatment	33	3,548,000	3,603,000	7,151,000
Prevention--underground mines	13	1,838,000	542,000	2,380,000
Prevention--surface sources	8	1,166,000	988,000	2,154,000
Prevention--new mining methods	3	740,000	280,000	1,020,000
Demonstration	10	3,618,000	1,755,000	5,373,000
Total	76	\$11,498,000	\$7,202,[illegible]	\$18,700,000

As of April 1973, 52 of the 76 projects had been completed. EPA's most significant acid drainage R&D effort was directed toward developing treatment techniques to eliminate or reduce the effects of acid drainage. EPA funded 33 extramural treatment projects at a Federal cost of about $3.5 million. As of April 1973, 26 of the projects had been completed.

EPA's projects for treating acid drainage are shown in the following table.

Technique	Number of projects	EPA's opinion of results	Federal funding
Lime-limestone neutralization	7	Successful	$1,464,000
Reverse osmosis and neutrolosis	4	Promising	368,000
Ion exchange	2	Promising	159,000
Pretreatment:			
Electrochemical	2	Promising	171,000
Ozone	2	Unsuccessful	36,000
Carbon	1	Unsuccessful	50,000
Mine drainage sludge	4	Promising	219,000
Other:			
Biological	3	Unsuccessful	210,000
Freezing process	1	Unsuccessful	10,000
Foam separation	2	Unsuccessful	137,000
Sulfide-sulfate	5	Unsuccessful	724,000
	33		$3,548,000

EPA's in-house research, costing about $1.1 million, was related to the treatment area and emphasized neutralization and reverse osmosis techniques.

EPA estimates that 70 percent of the technology required to adequately treat acid drainage has been developed. EPA officials consider their lime-limestone treatment the most successful. Most acid drainage treatment plants used during active mining operations add lime or limestone to the drainage to neutralize the acidity. Neutralization can produce water of acceptable quality for discharge into streams, but the water is not acceptable for municipal or industrial uses without further treatment.

We hired a consultant to help us evaluate EPA's program to develop acid drainage treatment technology. On the basis of our review and our consultant's evaluation, we believe EPA's treatment program has produced techniques which (1) have been demonstrated to be effective in treating acid drainage or (2) show promise of being effective but require more research. EPA's estimate of the technology already developed to adequately treat acid drainage from mines appears to be reasonable; its decisions on areas warranting more research and on the related funds required also appear reasonable.

We believe that EPA's April 1972 plan to develop required treatment technology by 1978 is reasonable, on the basis of the amount of work completed, the present level of funding, and the projects scheduled for future funding.

EPA estimates that 10 to 50 percent of the technology needed to prevent acid drainage has been developed. Techniques to prevent acid drainage from underground mines, which EPA officials consider to be the most critical technology needed, are only about 10-percent complete.

An EPA official said bulkhead seals had been the most successful underground acid drainage prevention technique developed. These seals are constructed with concrete, limestone, or other material and are used to block mine entrances or inner tunnels of abandoned mines. They are designed to prevent oxygen--needed for acid to form--from entering the mine and to retain drainage behind the seal.

EPA officials estimated that EPA has developed about 50 percent of the technology to prevent acid drainage from surface sources. The methods being developed include backfilling, regrading, contouring, revegetation, and building water impoundment areas. These methods also help to control other mine-related water pollution problems, such as erosion and siltation, and are primarily reclamation measures.

EPA's research into new mining methods involved developing alternative methods for mining both surface and underground coal with emphasis on reducing acid drainage. EPA funded three such projects to study two new different mining techniques known as oxygen-free mining and longwall stripping.

EQUIPMENT USED BY A MINER IN AN OXYGEN-FREE MINING EXPERIMENT

(EPA PHOTOGRAPH)

Oxygen-free mining is the mining of coal using self-supporting life systems similar to space suits. An inert gas is substituted for oxygen in a sealed underground mine, eliminating the presence of oxygen necessary for forming acid.

EPA is evaluating the longwall stripping technique, an adaptation of longwall mining. Longwall mining, a proven underground mining method commercially used in several European countries, uses mining equipment to support the mine roof while coal is mechanically removed. After the coal and the equipment are removed, the roof of the mine collapses, preventing the exposure of sulfur-bearing material to oxygen and water and thus preventing the formation of acid. EPA believes that applying the longwall stripping technique to certain strip-mining situations can prevent the formation of acid and the environmental destruction caused by some mining methods. EPA estimates that it has developed about 10 percent of the technology to prevent acid formation.

EPA's acid drainage demonstration program began in 1971. As of April 1973, seven grants, totaling about $3.5 million, had been awarded to five Appalachian States for demonstration projects in seven small river basins. Each grantee is to identify mine drainage pollution sources in the basin area, select the equipment and method to be applied to each, construct a treatment plant or implement the techniques selected, and monitor the results. They are to use techniques developed primarily through EPA research and development projects. As of April 1973, EPA was conducting feasibility studies for some of the seven projects, and the others were in the early construction stage.

IMPROVEMENTS NEEDED FOR INCREASED PROGRAM EFFECTIVENESS

Although EPA has accomplished some of its AST goals, the program would be more effective if program officials

--gave greater consideration to information and expertise available from sources outside EPA,

--concentrated available resources on high-priority problems rather than fragmenting the resources to cover all program areas, and

--directed their efforts more toward the needs of enforcement and standard-setting activities.

Need to consider other sources

We believe that all technology and expertise should be considered in planning and implementing an R&D program. We found that EPA had not always considered this technology; neither had it used the expertise available from sources outside the agency, such as other Federal agencies, private industry, universities, and the States, in planning and implementing its AST program. As a result, certain work plans were incomplete and some projects were misdirected.

Incomplete work plans

EPA developed work plans on a problem-by-problem basis for each program element. Some plans were written to solve a total problem while others were written to solve only a segment.

The work plan for the mine drainage treatment area was generally complete and included procedures for developing technology to control water pollution from mines. However, the work plans for three other areas reviewed were incomplete. These plans did not contain all the tasks necessary to solve the problems defined nor did they include input from outside sources.

For example, our consultant who reviewed the work plans for the animal feedlot area stated that the plan failed to build effectively upon information available from sources other than EPA.

Our consultant for the food and kindred products area stated that the work plans gave little regard to (1) defining what could reasonably be achieved within a definite period and (2) the feasible limits on technology that could be developed.

Comments from other Federal agencies, industrial associations, and the States supported the lack of outside input into EPA's program plans. For example, several industrial associations told us that they were unaware of and had no input into the planning of EPA's research needs, goals, and priorities and that EPA had not adequately defined some industrial problems.

EPA officials acknowledged that their work plans lacked adequate input from others who had expertise in specific areas and who are conducting similar R&D programs. They pointed out, however, that private industry was reluctant to coordinate its R&D efforts with EPA unless EPA provided funds for a project. Officials also said they lacked sufficient personnel to adequately coordinate their R&D efforts with those of other Federal agencies and the States.

Projects misdirected

Several projects funded in the animal feedlot and food and kindred products areas (1) did not relate to any objective or task in the work plans, (2) had, as an objective, the development of technology which had already been developed, demonstrated, or used, or (3) substantiated knowledge previously attained. For example, our consultant for the food and kindred products area concluded that the need for 26 of 48 projects funded in this area was questionable and that 3 definitely should not have been undertaken. He said a considerable number of projects were devoted to repeating and reevaluating waste treatment processes already tried and proven.

Our consultant for the animal feedlot area said the research needed in that area should be better defined and that there should be more input from animal feedlot operators in determining the most significant needs. In addition, he said that some projects had been directed toward obtaining information for researchers rather than for the feedlot operators who needed the information for immediate application.

Industrial associations also questioned the direction of some projects funded in the program. They stated that (1) some projects were not suitable for general application and needed better designs, (2) costs-benefits had been inadequately defined, and (3) funding had not been directed to the most significant problems.

Need to concentrate on high-priority problems

EPA established national priorities for AST program elements on the basis of the severity of their pollution problems and the need to demonstrate technology to solve them. Each problem was evaluated using this criteria, and the most significant problems were assigned priorities from 1 to 36. However, EPA allocated some funds to all program areas without strict regard to priority status. This resulted in inadequate funding of high-priority problems on a year-to-year basis, even though solving those problems would have had the greatest impact on improving the quality of the water.

Three of the seven AST program elements--heavy industry, light industry, and agricultural sources--accounted for the first six priorities. The following table shows EPA's estimate of the funding required for those priorities in fiscal year 1973 and the funds allocated.

Priority (note a)	Funds required in work plans	Funds allocated	Unfunded	Percent of required funding allocated
	(000 omitted)			
1	$ 3,615	$ 353	$ 3,262	9.7
2	805	325	480	40.4
3	1,416	377	1,039	26.6
4	4,975	1,020	3,955	20.5
5	3,909	153	3,756	3.9
6	2,293	943	1,350	41.1
Total	$17,012	$3,170	$13,842	18.6

[a] Each of these priorities had one or more work plans which included one or more projects.

The schedule shows that about $17 million was estimated as required to accomplish work plan objectives in fiscal year 1973; however, only about $3.2 million was allocated.

The amount of funds allocated to the six priorities was about 23 percent of the $13.9 million the program received in fiscal year 1973. The rest was allocated to lower priorities. For example, priorities 8 and 10 were each allocated more funding than any of the top 6. Collectively they were allocated about $5.6 million, or more than the top six combined. In addition, priorities 11 and 20 each were allocated more funding than 4 of the top 6, and priorities 13, 15, and 16 were each allocated more funding than priority 5.

The total funding allocated for some work plans was enough to cover only the salaries of in-house employees. EPA officials told us that, under these circumstances, the employees spent their time administering ongoing projects and researching available literature on work plan areas.

AST officials acknowledged that resources were fragmented among all program elements and that this had limited the effectiveness of their efforts. The officials said they had anticipated a certain funding level and had hired personnel with expertise in many different areas when the program was initiated. When less funds were received, they tried to maintain at least a minimum program for all program elements instead of reducing their staff.

They also told us that they funded all problem areas to develop expertise and maintain the interest of industry in all areas. In addition, officials said they depended on researchers' unsolicited proposals for projects to be funded. If acceptable proposals were not received for high-priority problem areas, proposals for lower priority areas were funded, while higher priority areas were sometimes funded at a minimum.

Needs of enforcement and standard-setting activities not always met

The AST program has not fully supported EPA's enforcement and standard-setting activities because of inadequate coordination between EPA's Office of Research and Development and the offices involved in those activities. According to an EPA official, the program's support of future needs may be inadequate because the AST program is not being funded at a level high enough to enable development and demonstration of technology when needed.

Officials of EPA's Office of Technical Analysis, which is responsible for assuring the adequacy and validity of (1) economic, scientific, and technical data and (2) evidence supporting the development of enforcement policy, individual enforcement actions, and other legal proceedings, stated that the program had not been responsive to their needs. They told us that coordination between enforcement and research personnel was lacking and that, until recently, they had no formal input into the planning and priorities of the program. They pointed out, however, that they had been able to use the expertise of AST personnel in enforcement actions.

The Office of Technical Analysis submitted a formal list of 11 long term needs to the Office of Research and Development for funding in fiscal year 1974. Only four of the needs were written up into work plans, and only two work plans were funded. Officials of the Office of Technical Analysis advised us that the two work plans which were funded did not appear to reflect an understanding of their requests. They told us the failure to prepare work plans and to fund all of their needs resulted because the Office of Research and Development misunderstood these needs.

EPA's Effluent Guidelines Division, Office of Air and Water Programs, establishes effluent standards and guidelines for industrial sources of pollution and furnishes technical assistance in enforcement actions. An official of that office told us that, in the past, extensive use had been made of AST project data. He said, however, that he did not believe the industrial program was going to respond to his office's future needs. According to him, even though the Federal Water Pollution Control Act Amendments of 1972 state that a major R&D effort will be undertaken to develop technology necessary to eliminate the discharge of pollutants, the industrial portion of the program was not being supported or funded by EPA at a level sufficient to develop, when needed, the technology on which to base effluent standards.

An official of EPA's Office of Permit Programs, which is responsible for developing plans and providing policy direction for implementing the National Pollutant Discharge Elimination System, told us that his office had not had any input into planning the AST program. He said that the projects funded under the program had little or no value for his office. In his opinion, many of the projects funded were directed toward unique situations at individual plants and had limited industrywide application.

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Even though EPA's AST program has not been fully responsive to its enforcement and standard-setting activities, EPA has developed and demonstrated some technology which (1) supports closed cycle systems for two industries, (2) is being used commercially, or (3) has industrywide application. Effluent limitations, guidelines, and standards for some industries, currently being developed, are based on program results. In addition, AST personnel have provided technical assistance to EPA's Office of Permit Programs, Office of Technical Analysis, and Office of Air and Water Programs.

The effectiveness of the AST program has been limited, however, because AST officials (1) have not adequately considered similar R&D efforts or the expertise available from other Federal agencies, private industry, universities, and the States in planning and implementing the AST program, (2) did not fund projects according to their priority status, and (3) did not adequately support enforcement and standard-setting activities. We believe that resolving these problems will make the AST program much more effective.

CHAPTER 3

STATUS OF THE AST PROGRAM IN RELATION TO NATIONAL GOALS

The Federal Water Pollution Control Act Amendments of 1972 state that the objective of the act is to restore and maintain the biological, physical, and chemical integrity of the Nation's waters. The act states that it is a national goal to eliminate the discharge of pollutants into navigable waters by 1985; also, it is a national policy that a major R&D effort be made to develop technology necessary to eliminate the discharge of pollutants into navigable waters, waters of the contiguous zone, and oceans.

The act also provides for applying the best practicable control technology available by July 1, 1977 (defined by AST officials as 85-percent removal of pollutants) and the best available technology economically achievable by July 1, 1983 (defined by AST officials as 95-percent removal of pollutants);[1] it establishes, as a national goal, zero discharge by 1985 (defined by AST officials as a discharge comparable in all water quality aspects with the receiving public body of water or as no discharge).[1]

The requirements for best practicable control technology and best available technology apply only to point (discharge pipe) sources of pollutants, whereas the zero discharge goal applies to all sources of pollutants.

ESTIMATE OF TECHNOLOGY DEVELOPMENT GOALS ACHIEVED AS OF JUNE 30, 1973

We requested that AST officials furnish us with an estimate of the proportion of the technology development goals that had been achieved (technology demonstrated to be both technically and economically feasible) for AST areas as of June 30, 1973, in relation to overall legislative and agency goals. Before the 1972 amendments were enacted, the AST Branch had established R&D goals to achieve interim levels of 85- and 95-percent pollution removal and ultimately zero discharge for industrial sources of pollution.

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[1] These are interim definitions of the AST Branch. EPA is in the process of determining the level of technology that will satisfy these statutory terms and is formally defining them as they relate to each type of industry.

AST officials based their estimates primarily on their judgment of what had been accomplished. Because these officials were not fully aware of the results of R&D outside of EPA, they gave little consideration to what other agencies, private industry, or the States had done, except when EPA funded projects conducted by others. The estimates were furnished according to program subelements. EPA officials emphasized that many active projects, when completed, would add to the technology already developed and demonstrated.

Industrial sources of water pollution

EPA's estimated percentages of technology developed for eliminating water pollution from industrial sources were related to the (1) best practicable control technology currently available (85-percent pollution removal), (2) best available technology economically achievable (95-percent pollution removal), and (3) zero discharge.

EPA's Estimates of the Levels of Technology Developed for Eliminating Water Pollution from Industrial Sources as of June 30, 1973

	Percent of established goals attained		
Element	Best practicable control technology (note a)	Best available technology	Zero discharge
Heavy industrial sources:			
Metal and metal products	75	25	5
Chemical and allied products	60	20	5
Power production	60	20	10
Petroleum and coal products	95	35	20
Machinery and transportation equipment manufacturing	75	25	10
Textile mill products	75	25	5
Rubber and plastic	80	25	10
Joint industrial-municipal wastes	75	25	10
Thermal pollution technology	80	40	20
Light industrial sources:			
Paper and allied products	90	25	10
Food and kindred products	90	20	5
Stone, clay, and glass products	75	25	15
Lumber and wood products	90	25	10
Miscellaneous industrial sources	70	25	10

[a] It was estimated that, when EPA's industrial program started in 1967, there was an average base of 10 percent of the required technology available for achieving this.

The schedule shows that significant results have been achieved toward developing the best practicable control technology. However, much remains to be developed and demonstrated to achieve the best available technology economically achievable and the 1985 goal of zero discharge.

We sent questionnaires to several national industrial associations and asked them to comment on EPA's estimate of water pollution control or removal technology development that had been achieved, but not necessarily implemented, in the industrial areas as of June 30, 1973.

The 16 associations responding to this question generally believed that EPA was optimistic about the level of technology development achieved. Some believed that:

--Estimates were based on limited single-plant demonstrations or pilot programs that were often conducted at new and larger plants which were not representative of the industry.

--Technology developed for one industry cannot necessarily be applied to another.

Other sources of water pollution

The act, as amended, does not mention control objectives for nonpoint sources of pollution, other than stating zero discharge as the national goal by 1985. EPA officials expressed the opinion that zero discharge is not economically or technically feasible for all nonpoint sources of pollution, so they established what they considered to be achievable control objectives for these sources. The objectives ranged from zero discharge for watercraft wastes and animal feedlots to improved management practices or process modifications to minimize pollution from all other nonpoint sources.

The following table shows EPA's estimate of the percentages of technology development goals attained for other than industrial AST program elements.

Element	Percent of established goals attained as of June 30, 1973
Transportation sources:	
Watercraft wastes	30
Recreation	15
Agricultural sources:	
Forestry and logging	20
Agricultural runoff	30
Irrigation return flows	30
Animal feedlots	35
Natural runoff	5
Aquaculture	40
Sludge disposal	50
Mining sources:	
Acid drainage:	
Basic research	90
Treatment	70
Prevention--surface mines	50
Prevention--underground mines	10
Prevention--new mining methods	10
Oil production	10
Oil shale	10
Phosphate mining	20
Other mining sources	10
Oil and hazardous materials spills:	
Hazardous material spills	10
Oil spills	20
Hydrologic modification:	
Construction	40
Dredging	15
Water resources development	-

EPA'S ESTIMATES OF ADDITIONAL FUNDING TO ACHIEVE TECHNOLOGY DEVELOPMENT GOALS

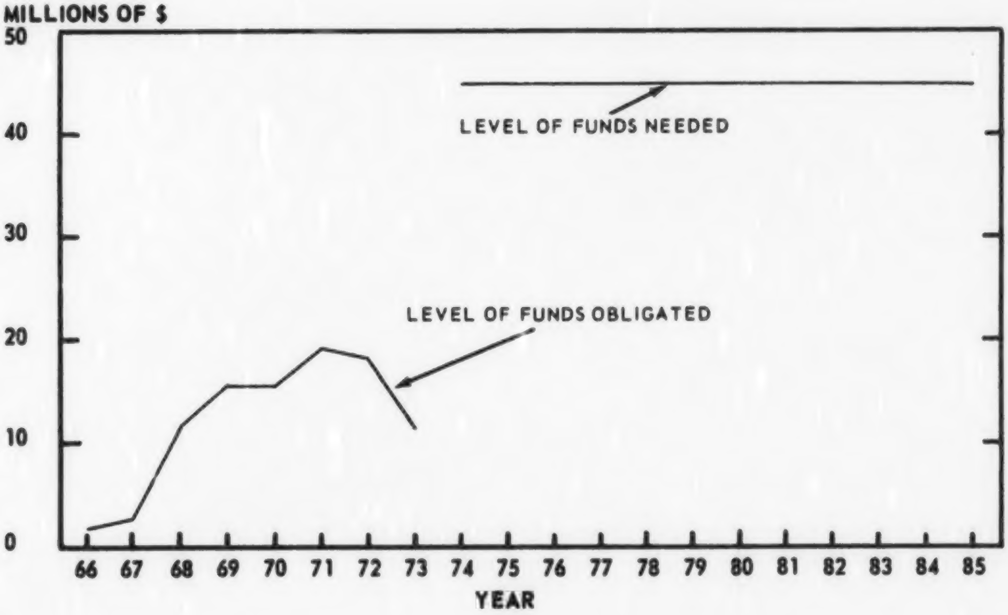
EPA officials furnished us with the following estimates of additional funding required to achieve legislative and agency goals for the AST area.

Element (note a)	Estimated additional funding required
	(millions)
Heavy industrial sources	$151.8
Light industrial sources	67.3
Transportation sources	5.0
Agricultural sources	76.5
Mining sources	117.0
Oil and Hazardous material spills	117.0
Hydrologic modification sources	8.0
	$542.6

[a] There are 33 subelements under the 7 program elements. (See app. VI.)

AST officials told us that, on the basis of past and current funding levels, totaling $96 million for fiscal years 1966-73, they did not expect to achieve their 1977, 1983, or 1985 goals. These officials estimated that about $45 million annually was needed for an effective AST program.

The following graph shows the level of funds EPA obligated for the AST area during fiscal years 1966-73 and EPA's estimate of the annual level of funds needed for fiscal years 1974-85.



As can be seen from the graph, EPA estimates it will need to increase its level of funding significantly to develop the technology required to meet 1985 goals. EPA officials advised us that, even if the technology were developed by 1985, a 5- to 7-year period would be required to implement it.

GAO OBSERVATION ON THE STATUS OF THE AST PROGRAM IN RELATION TO NATIONAL GOALS

Even though private industry disagrees with some of the levels of technology that EPA estimated had been achieved as of June 30, 1973, some progress has been made toward solving the Nation's water pollution problems in the AST area.

However, if EPA's estimate of about $543 million in additional funding is reasonable and if its current funding levels remain the same, it could take more than 45 years to achieve the established goals. Even with improved coordination of R&D efforts of our Federal agencies and private industry and States' limited efforts, it may be difficult to achieve the act's goals by 1985.

CHAPTER 4

NEED FOR IMPROVED COORDINATION

Improved coordination of R&D efforts in the AST area is needed to achieve the most effective results as soon as possible. EPA, other Federal agencies, and private industry have done extensive R&D in the AST area, and some States have conducted limited R&D programs. However, lack of effective coordination has caused overlapping and/or misdirected R&D.

THOSE INVOLVED IN R&D

The most extensive R&D efforts in the AST area have been conducted by EPA; the Department of Agriculture; the Department of the Interior; the Department of Defense (DOD); the Department of Transportation; and the Corps of Engineers, Department of the Army. The Department of Commerce, the Atomic Energy Commission, and the Tennessee Valley Authority also conducted R&D in the AST area.

We identified about $112 million which the Departments of Agriculture, Defense, the Interior, and Transportation and the Corps of Engineers obligated for R&D in the AST area during fiscal years 1969-73. We were unable to determine the total extent of these agencies' efforts because the way the agencies classified their water pollution R&D differed and because detailed accounting and budgeting data was not available.

The following table shows that 21 different Federal agencies have done R&D in the AST area. The agencies involved in each element ranged from 6 to 13.

Federal Agencies Funding R&D

Projects in the AST Area

	Element						
	Heavy industry	Light industry	Transportation	Agriculture	Mining	Oil and hazardous materials spills	Hydrologic modification
EPA	X	X	X	X	X	X	X
Department of Agriculture:							
Agricultural Research Service	X	X		X			X
Cooperative State Research Service		X		X	X		X
Economic Research Service		X		X			
Forest Service		X		X	X		
DOD:							
Navy	X		X	X		X	
Army	X		X			X	
Corps of Engineers			X		X	X	X
Air Force	X	X					
Department of the Interior:							
Office of Water Resources Research	X	X		X	X		X
Bureau of Mines					X		
Bureau of Land Management							X
Bureau of Reclamation				X			X
U.S. Geological Survey	X	X		X	X	X	X
Office of Saline Water	X			X	X		
Bureau of Sport Fisheries and Wildlife	X			X			
Department of Transportation:							
Federal Highway Administration			X			X	
Coast Guard			X				
Department of Commerce:							
National Oceanic and Atmospheric Administration	X	X	X	X	X	X	
Atomic Energy Commission	X					X	
Tennessee Valley Authority	X			X			
National Aeronautics and Space Administration	X	X					

Private industry and States

Thirteen industrial associations told us they were conducting R&D to prevent and abate water pollution. Eleven furnished cost data showing they had spent or obligated about $8 million between 1969 and 1973. In addition, 20 associations reported that their members had spent about $163 million on water pollution R&D during that same period.

Of 37 States which responded to our questionnaire, 9 reported that they conducted an R&D program in the AST area. Six reported total expenditures of about $1.3 million for the period 1969-73.

These reported amounts do not necessarily represent the total expenditures for water pollution R&D by private industry and the States because some associations and States did not respond to our questionnaire. However, the amounts indicate the significance of non-Federal organizations' R&D efforts.

LACK OF EFFECTIVE COORDINATION OF FEDERAL R&D

Because Federal R&D in the AST area is extensive, there is a need to (1) improve coordination, (2) prevent overlapping or uncoordinated parallel research which can result in inefficient use of funds, personnel, and time, and (3) insure that research results are fully used.

Although many Federal agencies were conducting R&D in the AST area, only EPA had specifically directed its program toward solving the Nation's water pollution problems. Most of the other Federal agencies considered their R&D efforts mission-related and not part of a formal water pollution abatement program.

The following examples illustrate overlapping R&D objectives of EPA and other Federal agencies in major AST elements.

Industrial sources

EPA	Develop and demonstrate industrial water reuse methods and product or byproduct recovery methods or process changes which will use less water than currently required or no water at all.
Agriculture	Expand the demand for farm and forest products by developing new and improved products and manufacturing processes which will use less water than currently used.
The Interior	Conduct water quality management and protection research to develop methods of controlling pollution, including research to improve conventional treatment methods, processes to treat new types of waste, and advanced treatment methods for more complete removal of pollutants.
DOD	Conduct research to define and study environmental pollution problems associated with military requirements, including studies of new processes and materials and treatment of industrial effluents and wastes.

Transportation sources

EPA	Develop technology to eliminate the discharge of wastes from watercraft and recreation activities.
Agriculture -	Promote community improvement and develop recreation, environment, and public services, which would include doing research on methods of alleviating water pollution and disposing of wastes.
DOD	Conduct research on such things as mobile package sewage treatment plants and systems for onshore and onboard treatment of wastes generated aboard watercraft.
Transportation	Conduct research to prevent damage to the marine environment, including research on shipboard sewage treatment.

Agricultural, mining, and hydrologic modification sources

EPA	Develop and demonstrate efficient management and system design practices which will minimize water pollution and develop treatment systems that can control, prevent, and abate water pollution from such sources as runoff, sedimentation, irrigation, erosion, construction, dredging, and drainage.
Agriculture	Develop management practices for conserving and efficiently using natural resources, including research to prevent and control runoff, erosion, and drainage and research to treat and manage saline irrigation water.
The Interior	Conduct research to improve our management of water, and cover such things as hydrologic effects of urbanization, logging, control of acid mine drainage, etc.
Transportation	Conduct research to prevent soil erosion and reduce the environmental hazards to water resources due to the highway system.

Some agencies have developed R&D programs for specific mission-related problems which parallel EPA work plans for solving the same problems. Two examples follow.

1. The Forest Service's R&D program of Forestry, Advanced Logging, and Conservation was established to provide environmentally suitable timber-harvesting methods. The program's three objectives are to (1) promote better understanding of the relationships of timber-harvesting and protection of the forest ecosystem, (2) develop and test improved logging equipment and forest transport systems, and (3) demonstrate and apply both current and new technology. The program is expected to cost about $10 million a year for 5 years (1973-77).

   EPA's objective in forestry and logging R&D is to demonstrate improved forest fertilization and logging practices to minimize runoff and organic and sediment pollution. EPA plans to use management techniques that minimize effects on the environment.

   EPA had obligated $87,552 as of fiscal year 1972 and allocated $92,500 for fiscal year 1973 to meet this objective..

2. During fiscal years 1969-73, the Corps of Engineers made a study to provide more definitive information on the environmental impact of dredging and dredge spoil disposal operations and to develop new or improved disposal practices. Through fiscal year 1973 about $0.8 million was funded for this study.

   The Corps plans to spend $30 million more over the next 5 fiscal years for further investigation and implementation of environmentally compatible methods of disposing of dredged materials.

   EPA's objectives in the dredging area are to (1) quantify the pollution potential of dredging and dredged spoil, (2) develop improved methods and mechanisms for disposing of dredged spoils, and (3) promote development of improved dredging methods and techniques. EPA had obligated $288,699 as of fiscal year 1972, which included $58,310 for a project called Dredge Spoil Disposal Guidelines.

Agency officials at the headquarters level and individual researchers in the field were generally aware that others were conducting R&D in given areas. They were, however, unaware of the specific projects being conducted, even though the research was directed toward the same or similar problems in some cases.

For example, we identified 263 projects which Agriculture and the Interior funded at $24.5 million. We discussed these projects with EPA officials responsible for planning EPA's efforts in those areas.

Of the 263 projects, EPA

--was directly aware of and had input into 13 projects,

--was indirectly aware of and had no input into 72 projects, and

--was not aware of 178 projects.

Of the 263 projects

--78 were considered useful by EPA officials, including 33 of which EPA had no prior knowledge;

--37 duplicated EPA projects, or EPA's projects duplicated the efforts of the other agencies; and

--148 were not considered useful by EPA because they were directed toward studying, rather than solving, problems.

EPA officials told us that many of the 148 projects could have been more useful if EPA had had input into their scope and objectives.

Problems with R&D data systems

Agency officials told us that Federal and non-Federal data systems were used to share research information. However, these officials generally agreed that the data in the systems was not complete or current. The different ways agencies classified R&D efforts also tended to limit the usefulness of the data systems for coordination purposes.

For example, EPA classified its projects according to program elements while Agriculture and the Interior used the Council on Water Resources Research classification system; DOD's system also differed. As a result, many researchers used only the system associated with their own agency and did not attempt to determine whether others were doing or had done similar research. (See ch. 5, vol. I.)

Since EPA is responsible for cleaning up the Nation's waterways, we attempted to classify all Federal agencies' R&D efforts using EPA's classification system. However, because other agencies' systems of classifying projects were not compatible with EPA's, we could not identify and analyze the full extent of their R&D efforts. The agencies themselves could not fully identify the extent of their R&D in accordance with EPA's program elements.

MEANS OF IMPROVING COORDINATION

Officials from Federal agencies other than EPA said an overall plan outlining a national water pollution R&D program was needed to coordinate all water pollution research, but that no one agency could develop the plan alone. They suggested there should be a plan for each problem area with input from all sources of expertise and that the combination of the separate plans should form the basis for the overall R&D plan.

These officials told us that their agencies have expertise that could help solve water pollution problems. For example, Agriculture officials said water pollution from agricultural activities are Agriculture's problems and that they have the expertise to solve them. They said not only was there a lack of coordination of water pollution R&D among departments but also between agencies and bureaus within departments. The officials told us that they had tried to coordinate their mission-related research projects with EPA but had had difficulty because EPA had no focal point for coordinating with other agencies and because EPA was constantly changing its personnel.

EPA officials agreed that an overall plan for the AST area was needed to fully use all available resources. They said one agency did not need to be the lead agency for all R&D if others, designated as lead agencies, for R&D on certain problems, committed themselves to completing needed research on time. The officials added that other agencies' R&D efforts could be more responsive to EPA's needs and could help it solve the Nation's water pollution problems if there was better coordination. They said, however, effective coordination would require more EPA personnel.

National industrial association officials also stated a need for better coordination. They expressed the opinion that they should have input into determining AST research needs, goals, and priorities and that an overall R&D plan would help prevent duplicative and conflicting efforts.

Some States also agreed that improved coordination was needed because Federal agencies' R&D programs had been duplicative.

EPA LOCATIONS VISITED

AST Branch
Office of Research and Development
Washington, D.C.

Office of Permit Program
Office of Technical Analysis
Office of the Assistant Administrator for Enforcement and General Counsel
Washington, D.C.

Effluent Guidelines Division
Office of the Assistant Administrator for Air and Water Programs
Washington, D.C.

National Environmental Research Center
Corvallis, Oregon
Pacific Northwest Water Laboratory
Corvallis, Oregon
Grosse Ile Field Station
Grosse Ile, Michigan
Robert S. Kerr Water Research Center
Ada, Oklahoma
Southeast Water Laboratory
Athens, Georgia

National Environmental Research Center
Cincinnati, Ohio
Advanced Waste Treatment Research Laboratory
Cincinnati, Ohio
Analytical Quality Control Laboratory
Cincinnati, Ohio
Water Supply Research Laboratory
Cincinnati, Ohio
Edison Water Quality Research Laboratory
Edison, New Jersey

Region V
Chicago, Illinois

EPA PROJECT SITES VISITED

American Enka Corporation, Enka, North Carolina

American Oil Research Center, Whiting, Indiana

Black, Sivalls, and Bryson, Incorporated, Pittsburgh, Pennsylvania

Continental Can Company, Incorporated, Paperboard and Kraft Paper Division, Hodge, Louisiana

The Dow Chemical Company, Freeport, Texas

The General Tire and Rubber Company, Odessa, Texas

Green Bay Packaging, Incorporated, Green Bay, Wisconsin

The Miami Conservancy District, Franklin, Ohio

OTHER FEDERAL AGENCIES VISITED

ATOMIC ENERGY COMMISSION

Headquarters, Germantown, Maryland
Oak Ridge National Laboratory
  Oak Ridge, Tennessee
Savannah River Ecological Laboratory
  Aiken, South Carolina

DEPARTMENT OF AGRICULTURE

Headquarters:
  Agricultural Research Service
    Beltsville, Maryland
  Cooperative State Research Service
    Washington, D.C.
  Division of Environmental Research, U.S. Forest Service
    Washington, D.C.
  Economic Research Service
    Washington, D.C.
  Science and Education
    Washington, D.C.
Field:
  Forest Products Laboratory
    Madison, Wisconsin
  North Appalachian Experimental Watershed Research Center
    Coshocton, Ohio
  Northeastern Forest Experiment Station
    Berea, Kentucky
  Northern Utilization Marketing and Nutrition Research
    Division Laboratory
    Peoria, Illinois
  Richard B. Russell Agricultural Research Center
    Athens, Georgia
  Soil and Water Conservation Research Division
    Fort Collins, Colorado
  Southern Great Plains Watershed Research Center
    Chickasha, Oklahoma
  Southern Piedmont Soil Conservation Research Center
    Watkinsville, Georgia
  U.S. Agricultural Water Quality Management Laboratory
    Durant, Oklahoma
  U.S. Salinity Laboratory
    Riverside, California

DEPARTMENT OF AGRICULTURE (continued)

Field (continued):
- U.S. Sedimentation Laboratory
  Oxford, Mississippi
- U.S. Water Conservation Laboratory
  Phoenix, Arizona
- Western Utilization Research and Development Division
  Laboratory
  Albany, California

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
Washington, D.C.

DEPARTMENT OF DEFENSE

Department of the Air Force, Washington, D.C.
Department of the Army, Corps of Engineers, Headquarters,
Washington, D.C.
Department of the Navy, Washington, D.C.
Naval Civil Engineering Laboratory
Port Hueneme, California

DEPARTMENT OF THE INTERIOR

Headquarters, Washington, D.C.:
- Bureau of Land Management
- Bureau of Mines
- Bureau of Reclamation
- Bureau of Sport Fisheries and Wildlife
- Office of Saline Water
- Office of the Science Advisor
- Office of Water Resources Research
- U.S. Geological Survey

Field:
- Geological Survey Water Resources Division
  Denver, Colorado

DEPARTMENT OF TRANSPORTATION

Assistant Secretary for Environment and Urban Systems
Washington, D.C.
Federal Highway Administration
Washington, D.C.

DEPARTMENT OF TRANSPORTATION (continued)

Field (continued):
  U.S. Coast Guard
    Washington, D.C.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Headquarters, Washington, D.C.

NATIONAL SCIENCE FOUNDATION

Headquarters, Washington, D.C.

TENNESSEE VALLEY AUTHORITY

Headquarters, Knoxville, Tennessee

NATIONAL INDUSTRIAL ASSOCIATIONS WHICH RECEIVED GAO QUESTIONNAIRES (note a)

ALLIED STONE INDUSTRIES
c/o The Waller Brothers Stone Company
McDermott, Ohio 45652

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS
P.O. Box 12215
Research Triangle Park
North Carolina 27709

American Bleached Shellac Manufacturers Association
425 Park Avenue
New York, New York 10022

AMERICAN BRUSH MANUFACTURERS ASSOCIATION
1900 Arch Street
Philadelphia, Pennsylvania 19103

American Coke and Coal Chemicals Institute
1010 16th Street, NW.
Washington, D.C. 20036

AMERICAN CULTURED DAIRY PRODUCTS INSTITUTE
910 17th Street, NW.
Washington, D.C. 20006

AMERICAN DYE MANUFACTURERS INSTITUTE
74 Trinity Place
New York, New York 10006

AMERICAN ELECTROPLATER'S SOCIETY, INC.
56 Melmore Gardens
East Orange, New Jersey 07017

AMERICAN FEED MANUFACTURERS ASSOCIATION, INC.
1701 North Fort Meyer Drive
Arlington, Virginia 22209

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[a] Industrial associations which responded to the questionnaire are capitalized (55 of 74).

AMERICAN FOUNDRYMEN'S SOCIETY
Golf and Wolf Roads
Des Plaines, Illinois 60016

American Frozen Food Institute
919 18th Street, NW.
Washington, D.C. 20006

AMERICAN IRON AND STEEL INSTITUTE
150 East 42d Street
New York, New York 10017

AMERICAN MEAT INSTITUTE
59 East Van Buren Street
Chicago, Illinois 60605

AMERICAN MINING CONGRESS
1100 Ring Building
18th Street, NW.
Washington, D.C. 20036

AMERICAN PAPER INSTITUTE, INC.
260 Madison Avenue
New York, New York 10016

AMERICAN PETROLEUM INSTITUTE
1801 K Street, NW.
Washington, D.C. 20006

AMERICAN PETROLEUM REFINERS ASSOCIATION
1110 Ring Building
Washington, D.C. 20036

AMERICAN SUGAR CANE LEAGUE OF THE UNITED STATES
414 Whitney Building
New Orleans, Louisiana 70130

AMERICAN TEXTILE MANUFACTURERS INSTITUTE, INC.
1120 Connecticut Avenue, NW.
Washington, D.C. 20036

AMERICAN WATERWORKS ASSOCIATION
2 Park Place
New York, New York 10016

ANTHRACITE INSTITUTE
240 North Third Street
Harrisburg, Pennsylvania 17101

BEET SUGAR DEVELOPMENT FOUNDATION
156 South College Street
P.O. Box 538
Fort Collins, Colorado 80522

BITUMINOUS COAL OPERATORS ASSOCIATION
918 16th Street, NW.
Washington, D.C. 20006

BREWERS ASSOCIATION OF AMERICA
541 West Randolph Street
Chicago, Illinois 60606

CHEMICAL SPECIALTY MANUFACTURERS ASSOCIATION
50 East 41st Street
New York, New York 10017

CONSTRUCTION INDUSTRY MANUFACTURERS ASSOCIATION
111 East Wisconsin Avenue
Milwaukee, Wisconsin 53202

COORDINATING RESEARCH COUNCIL
30 Rockefeller Plaza
New York, New York 10020

Copper Development Association, Inc.
405 Lexington Avenue
New York, New York 10017

CORN REFINERS ASSOCIATION, INC.
1001 Connecticut Avenue, NW.
Washington, D.C. 20036

GLASS CONTAINER MANUFACTURERS INSTITUTE, INC.
1800 K Street, NW.
Washington, D.C. 20006

Grocery Manufacturers of America, Inc.
1425 K Street, NW.
Washington, D.C. 20005

EDISON ELECTRIC INSTITUTE
90 Park Avenue
New York, New York 10016

Fuels Research Council
1130 17th Street, NW.
Washington, D.C. 20036

Idaho Potato Processors
Box 10
Boise, Idaho 83707

Independent Petroleum Association of America
1101 16th Street, NW.
Washington, D.C. 20036

Independent Refiners Association of America
806 15th Street, NW.
Room 1201
Washington, D.C. 20005

Institute of Paper Chemistry
Appleton, Wisconsin 54911

INTERNATIONAL COPPER RESEARCH ASSOCIATION, INC.
825 Third Avenue
New York, New York 10020

INTERNATIONAL INSTITUTE OF SYNTHETIC RUBBER PRODUCERS
45 Rockfeller Plaza
New York, New York 10020

LEAD INDUSTRIES ASSOCIATION, INC.
292 Madison Avenue
New York, New York 10017

Machinery and Allied Products Institute
1200 18th Street, NW.
Washington, D.C. 20036

MANUFACTURING CHEMISTS ASSOCIATION
1825 Connecticut Avenue, NW.
Washington, D.C. 20009

METAL POWDER INDUSTRIES FEDERATION
210 East 42d Street
New York, New York 10017

METAL TREATING INSTITUTE, INC.
Box 448
Rye, New York 10580

MOTOR VEHICLE MANUFACTURERS ASSOCIATION OF THE UNITED STATES, INC.
1619 Massachusetts Avenue, NW.
Washington, D.C. 20036

NATIONAL AGRICULTURAL CHEMICALS ASSOCIATION
Suite 514, Madison Building
1155 15th Street, NW.
Washington, D.C. 20005

NATIONAL ASSOCIATION OF MANUFACTURERS
1133 15th Street, NW.
Washington, D.C. 20005

NATIONAL ASSOCIATION OF METAL FINISHERS
284 Lorraine Avenue
Upper Montclair, New Jersey 07043

National Association of Pharmaceutical Manufacturers
101 Park Avenue
New York, New York 10017

NATIONAL ASSOCIATION OF PHOTOGRAPHIC MANUFACTURERS, INC.
600 Mamaroneck Avenue
Harrison, New York 10528

National Association of Secondary Material Industries, Inc.
330 Madison Avenue
New York, New York 10017

NATIONAL CANNERS ASSOCIATION
1133 20th Street, NW.
Washington, D.C. 20036

National Coal Association
1130 17th Street, NW.
Washington, D.C. 20036

National Council of Coal Lessors
1425 H Street, NW.
Washington, D.C. 20005

NATIONAL COUNCIL OF THE PAPER INDUSTRY FOR AIR AND STREAM IMPROVEMENT
260 Madison Avenue
New York, New York 10016

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
155 East 44th Street
New York, New York 10017

National Paint and Coatings Association
1500 Rhode Island Avenue, NW.
Washington, D.C. 20005

NATIONAL PETROLEUM COUNCIL
1625 K Street, NW.
Washington, D.C. 20006

NATIONAL PETROLEUM REFINERS ASSOCIATION
1725 DeSales Street, NW.
Washington, D.C. 20036

NON-FERROUS FOUNDERS' SOCIETY, INC.
21010 Center Ridge Road
Cleveland, Ohio 44116

NORTHERN TEXTILE ASSOCIATION
211 Congress Street
Boston, Massachusetts 02110

PHARMACEUTICAL MANUFACTURERS ASSOCIATION
1155 15th Street, NW.
Washington, D.C. 20005

PICKLE PACKERS INTERNATIONAL
Box 31
St. Charles, Illinois 60174

POTATO ASSOCIATION OF AMERICA
c/o University of Maine
114 Deering Hall
Orono, Maine 04473

POTATO CHIP INSTITUTE INTERNATIONAL
946 Hanna Building
Cleveland, Ohio 44115

SYNTHETIC ORGANIC CHEMICAL MANUFACTURERS ASSOCIATION
1075 Central Park Avenue
Scarsdale, New York 10583

TANNER'S COUNCIL OF AMERICA
411 Fifth Avenue
New York, New York 10016

Technical Association of the Pulp and Paper Industry
360 Lexington Avenue
New York, New York 10017

THE ALUMINUM ASSOCIATION
750 Third Avenue
New York, New York 10017

THE FERTILIZER INSTITUTE
1015 18th Street, NW.
Washington, D.C. 20036

The Rubber Manufacturers Association, Inc.
444 Madison Avenue
New York, New York 10022

The Soap and Detergent Association
475 Park Avenue
New York, New York 10016

UNITED STATES BREWERS ASSOCIATION, INC.
1750 K Street, NW.
Washington, D.C. 20006

WHEY PRODUCTS INSTITUTE
130 North Franklin Street
Chicago, Illinois 60606

MAJOR OBJECTIVES FOR EACH AST ELEMENT
AND THE ESTIMATED YEAR THEY WILL BE ACHIEVED

Element	Major objectives	Year to be achieved
Heavy and light industrial sources	Implement best practicable control technology, which AST officials have defined as being 85-percent removal of pollutants, not later than July 1, 1977.	1974
	Implement best available technology, which AST officials have defined as being 95-percent removal of pollutants, not later than July 1, 1983.	1983
	Implement zero discharge, which EPA has defined as being the elimination of discharge of pollutants by using industrial practices resulting in --a discharge comparable in all water quality aspects with the receiving public body of water or --no discharge of any waterborne effluent to any public body of water.	1985
Transportation sources:		
Watercraft wastes	No discharge of wastes from watercraft or recreation.	1977 1978

Element	Major objectives	Year to be achieved
Agricultural sources: Forestry and logging	Demonstrate improved forest fertilization and logging practices to minimize runoff and organic and sediment pollution. 1. Use management techniques that minimize effects on the environment.	1981
Agricultural runoff	Develop and demonstrate practices and systems to minimize runoff of pollutants. 1. Quantify pesticide and nutrient runoff. 2. Develop pesticide and nutrient uses criteria. 3. Develop improved crop additive formulations. 4. Use different less toxic pesticides where possible, to insure that dispersement techniques mitigate deposition or movement to watercourses.	1981
Irrigation return flows	Develop and demonstrate efficient irrigation management and system design practices. 1. Treat and control irrigation return flow to remove nitrates.	1983-85

Element	Major objectives	Year to be achieved
	2. Demonstrate complete structural control to minimize leaching of salts from soils.	
	3. Demonstrate methods to minimize water use and dissolved solids in irrigation return flows.	
	4. Develop enforceable water quality standards and treatment systems that can be applied to agricultural activities.	
	5. Develop enforceable water quality standards and treatment systems that can be applied to agricultural activities.	
	6. Require irrigators to use water more effectively	
Animal feedlots	Demonstrate animal management systems that result in effluents which meet water quality standards--zero discharge.	1983-85
	1. Develop design manual to provide guidelines for control, treatment, and disposal of runoff.	
	2. Develop treatment-recycle concepts to produce effluents that	

Element	Major objectives	Year to be achieved
	will meet water quality standards. 3. Develop treatment concepts that use land as secondary and tertiary treatment systems. 4. Demonstrate systems that convert the high food and resource content of manure to animal feeds or useful commercial products. 5. Collect runoff and recycle it to the land and consider completely enclosed feeding facilities for managing liquid waste and abating air pollution.	
Natural runoff	Characterize the nature and extent of naturally occurring runoff from land, salt-bearing geologic formations, mineral springs and wells, and other sources.	1980
Aquaculture	Develop and demonstrate fish and seafood management systems that result in effluents that meet discharge and/or effluent standards. 1. Direct R&D to treatment-recycle and disposal of waste to the land.	1981

Element	Major objectives	Year to be achieved
Sludge disposal	Develop and demonstrate technology for disposing of municipal and industrial sludges on agricultural lands.	1981
	1. Quantify soil-loading capacities.	
	2. Quantify concentration of hazardous elements in sludges for various crops.	
	3. Demonstrate pretreatment techniques for families of sludges.	
Mining sources	Develop and demonstrate technology required to abate pollution caused from present mining operations and nonoperating mines and to allow future mining without environmental degradation.	
	Oil shale	1978
	Other	1990
Oil and hazardous material spills	Establish and enforce effective regulations to control and clean up oil and hazardous materials spills by responsible parties.	1983
	Provide a fully adequate Federal response to clean up spills when responsible parties fail to act.	1983

Element	Major objectives	Year to be achieved
	Implement a comprehensive prevention program that will eliminate all preventable spills and decrease the effect of spills caused by acts of God and unavoidable accidents.	1976
	Promote and assist State and local agencies in developing respective contingency plans, responsive capabilities, and prevention programs, so that they might eventually assume major responsibility in controlling oil and hazardous materials pollution.	1983
	Provide a research and development program and advanced technology to carry out the above.	1983
Hydrologic modifications:		
Construction	Develop and demonstrate technology for controlling and preventing erosion and siltation at construction projects sites.	1976
Dredging	Quantify and qualify the pollution potential of dredging and dredged spoil.	1977
	Develop improved methods and mechanisms for disposing of dredged spoils.	1977

Element	Major objectives	Year to be achieved
	Promote development of improved dredging methods and techniques.	1977
Water resources development	Quantify pollution of water resources development projects. This must include institutional constraints and interfaces as well as the technical aspects of adverse hydrologic modifications.	1980

EPA'S OBLIGATIONS FOR THE AST
EXTRAMURAL PROGRAM FOR FISCAL YEARS 1966-73
AND ADDITIONAL FUNDING REQUIRED TO MEET PROGRAM OBJECTIVES

Elements	Obligations	Estimated additional funding required
	(000 omitted)	
Heavy industrial sources:		
Metal and metal products	$ 3,685	$ 19,730
Chemical and allied products	5,469	34,680
Power production	364	3,320
Petroleum and coal products	1,508	10,790
Machinery and transportation equipment manufacturing	114	4,560
Textile mill products	2,778	17,980
Rubber and plastics	392	4,480
Joint industrial-municipal	5,972	33,240
Thermal pollution technology	550	23,010
Light industrial sources:		
Paper and allied products	7,761	18,860
Food and kindred products	8,465	26,930
Stone, clay, and glass products	253	8,910
Lumber and wood products	594	3,620
Miscellaneous industrial sources	1,681	8,950
Total	$39,586	$219,060
Transportation sources:		
Watercraft wastes	$ 2,830	$ 2,000
Recreation	422	3,000
Agricultural sources:		
Forestry and logging	181	1,500
Agricultural runoff	1,515	15,000
Irrigation return flows	3,481	20,000
Animal feedlots	3,585	20,000
Natural runoff	-	5,000
Aquaculture	35	5,000
Sludge disposal	-	10,000
Mining sources:		
Mine drainage	13,775	110,000
Oil production	241	2,000
Oil shale	39	1,000
Other mining sources	206	2,000
Phosphate mining	179	2,000
Oil and hazardous materials spills:		
Hazardous material spills	$ 3,989	$ 63,000
Oil spills	11,651	54,000
Hydrologic modifications:		
Construction	759	2,000
Dredging	289	4,000
Water resources development	10	2,000
Total	43,207	323,500
Total	$82,793	$542,560

EPA'S OBLIGATIONS FOR THE AST

EXTRAMURAL PROGRAM BY FISCAL YEAR AND PROGRAM SUBELEMENTS

Element	1967 (note a)	1968	1969	1970	1971	1972	1973	Total
	(000 omitted)							
Heavy industrial sources:								
Metal and metal products	$ -	$ 1,066	$ 616	$ 285	$ 540	$ 655	$ 523	$ 3,685
Chemical and allied products	-	56	1,674	1,654	1,011	459	615	5,469
Power production	-	-	-	-	46	-	318	364
Petroleum and coal products	-	222	424	120	699	-	43	1,508
Machinery and transportation equipment manufacturing	-	40	-	-	31	35	8	114
Textile mill products	-	633	68	324	537	769	447	2,778
Rubber and plastics	-	-	-	-	392	-	-	392
Joint industrial-municipal	701	1,476	1,515	894	705	631	50	5,972
Thermal pollution technology	-	-	-	-	-	550	-	550
Total	$ 701	$ 3,493	$ 4,297	$ 3,277	$ 3,961	$ 3,099	$ 2,004	$20,832
Light industrial sources:								
Paper and allied products	$ 379	$ 2,889	$ 1,878	$ 559	$ 527	$ 1,055	$ 474	$ 7,761
Food and kindred products	1,064	1,221	1,988	2,245	772	566	609	8,465
Stone, clay, and glass products	-	82	-	2	85	-	84	253
Lumber and wood products	-	66	21	21	100	293	93	594
Miscellaneous industrial sources	105	621	89	366	324	126	50	1,681
Total	$1,548	$ 4,879	$ 3,976	$ 3,193	$ 1,808	$ 2,040	$ 1,310	$18,754
Transportation sources:								
Watercraft wastes	$ -	$ -	$ 331	$ 74	$ 1,829	$ 134	$ 462	$ 2,830
Recreation	-	173	-	28	198	-	43	442
Total	$ -	$ 173	$ 331	$ 102	$ 2,027	$ 134	$ 505	$ 3,272
Agriculture sources:								
Forestry and logging	$ -	$ -	$ -	$ 38	$ -	$ 50	$ 93	$ 181
Agricultural runoff	-	-	147	113	293	585	377	1,515
Irrigation return flows	67	350	286	910	883	439	546	3,481
Animal feedlots	-	-	512	777	343	1,010	943	3,585
Natural runoff	-	-	-	-	-	-	-	-
Aquaculture	-	-	-	-	-	-	35	35
Total	$ 67	$ 350	$ 945	$ 1,838	$ 1,519	$ 2,084	$ 1,994	$ 8,797
Mining sources:								
Mine drainage	[a]$ 119	$ 1,987	$ 2,916	$ 2,035	$ 2,937	$ 1,543	$ 2,238	$13,775
Oil production	-	185	26	30	-	-	-	241
Oil shale	-	-	39	-	-	-	-	39
Other mining sources	-	-	-	87	-	19	100	206
Phosphate mining	-	-	154	-	-	-	25	179
Total	$ 119	$ 2,172	$ 3,135	$ 2,152	$ 2,937	$ 1,562	$ 2,363	$14,440
Oil and hazardous material spills:								
Hazardous spills	$ -	$ -	$ -	$ 60	$ 1,497	$ 1,243	$ 1,189	$ 3,989
Oil spills	-	26	1,971	2,248	1,927	3,302	2,177	11,651
Total	$ -	$ 26	$ 1,971	$ 2,308	$ 3,424	$ 4,545	$ 3,366	$15,640
Hydrologic modification:								
Construction	$ -	$ -	$ 41	$ 280	$ 75	$ 363	$ -	$ 759
Dredging	-	-	-	-	75	214	-	289
Water resources development	-	-	-	10	-	-	-	10
Landfill	-	-	-	-	-	-	-	-
Total	$ -	$ -	$ 41	$ 290	$ 150	$ 577	$ -	$ 1,058
Total	$2,435	$11,093	$14,626	$13,160	$15,826	$14,041	$11,542	$82,793

[a] Includes $40,000 funded in fiscal year 1966.

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